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RELEVANT AND IRRELEVANT PICTORIAL COLOR CUES IN DISCRIMINATION LEARNING--MANIPULATION OF CUE RELEVANCE, INSTRUCTIONAL STIMULI, PRACTICE PROCEDURES AND INTERVALS, SHAPE DISCRIMINABILITY, TEST PROCEDURES AND AGE OF SUBJECT.

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DESCRIPTORS- *PICTORIAL STIMULI, *DISCRIMINATION LEARNING, *PAIRED ASSOCIATE LEARNING, *PROMPTING, *AGE DIFFERENCES, LEARNING THEORIES

BECAUSE THE EFFECTIVENESS OF COLOR IN PICTORIAL INSTRUCTIONAL MATERIALS WAS INDETERMINATE, 5 EXPERIMENTS WERE DESIGNED TO INVESTIGATE EFFECTS OF COLOR CUE RELEVANCE (DEFINED AS A CORRELATION OVER TRIALS BETWEEN PRESENTATION OF A GIVEN STIMULUS CUE AND REINFORCEMENT OF A PARTICULAR RESPONSE) ON PAIRED-ASSOCIATE LEARNING. OTHER INDEPENDENT VARIABLES ARE LISTED IN THE SUB-TITLE. STIMULI WERE VARIED WITH RESPECT TO INTER- AND INTRA-LIST DIFFERENCES IN DISCRIMINABILITY AND MEANINGFULNESS OF SHAPES. MANY SIGNIFICANT RELATIONSHIPS WERE FOUND BY ANALYSIS OF VARIANCE OF ERRORS IN ALL TRIALS AND ALL EXPERIMENTS. IN GENERAL, A POSITIVE RELATION WAS FOUND BETWEEN COLOR RELEVANCE AND NUMBER OF ERRORS DURING TRIALS OF COMPOUND STIMULUS ACQUISITION. SINCE SUBJECTS WERE 10 YEAR-OLDS AND ADULTS, A TENTATIVE CONCLUSION WAS THAT FACILITY IN CUE SELECTION IS A POSITIVE FUNCTION OF AGE. THIS RELATION MAY BE MEDIATED BY PRESENCE OF COMPOUND STIMULI WITHOUT COLOR COMPONENTS, AND ORDER OF SELECTION OF SHAPE AND COLOR COMPONENTS. FURTHER WORK ON MEDIATION, DISCRIMINATION, AND PROMPTING IS SUGGESTED. RESULTS ARE DISCUSSED IN TERMS OF STIMULUS-RESPONSE MODELS AND COGNITIVE DEVELOPMENT OF CHILDREN. THEY SUPPORT THE ASSUMPTION THAT COLOR CODING EFFECTS MAY BE INTERFERING OR FACILITATING, DEPENDING ON FACTORS OTHER THAN VISUAL DISPLAY CHARACTERISTICS. STATISTICAL TABLES, EXPERIMENTAL MATERIALS, AND REFERENCES ARE GIVEN. (LH)

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RELEVANT AND IRRELEVANT PICTORIAL COLOR CUES IN DISCRIMINATION LEARNING: Manipulation of Cue Relevance, Instructional Stimuli, Practice Procedures and Intervals, Shape Discriminability, Test Procedures and Age of Subject

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INTRODUCTION

Comparisons of the instructional effectiveness of color (chromatic) and black and white (achromatic) versions of pictorial materials in school learning contexts have not yielded consistent results. This fact has led persons reviewing research on instructional use of color to suggest that the effect of color cues was frequently obscured by failure to control adequately the relevance of color cues (Miller, 1957; Hoban, 1960; Lumsdaine, 1964; Travers, 1964).

Cue relevance may be defined in terms of a correlation over trials between the presentation of a given stimulus cue and the reinforcement of a particular response. When so defined the presentation of relevant color cues as one component of a compound stimulus which includes multiple relevant components has been found to facilitate acquisition in tasks such as concept identification (Bourne & Restle, 1959) and paired-associate learning (Weiss & Margolius, 1954). However, in many instructional contexts, such as the acquiring of distinctive labeling responses to numbers, letters, maps and other shape objects which are initially color coded, color cues are relevant during acquisition but are not present on retention trials. It has been generally found that the addition of strong relevant color cues during acquisition trials only, has had an interfering effect upon performance in a transfer task in which these cues were absent when compared with transfer task performance following acquisition training in the absence of relevant color cues. This interfering effect has been shown to vary as a function of relative meaningfulness (Underwood, 1963), formal similarity (Cohen & Musgrave, 1966) orienting task (Mechanic, 1962) and incentive instructions (Bahrick, 1954) associated with the color and shape components respectively. These findings of interference are also generally consistent with the limited information processing model of Broadbent as applied to predicted interference associated with visual embellishments by Travers (1964).

Two procedures, however, seem to result in a decrease if not a reversal of the interfering cue competition phenomenon. Under appropriate orienting task instructions both elements of a compound stimulus have been conditioned with no evidence of competitive interference (Mechanic, 1962). In addition appropriate instructions have been shown to increase the probability of forming mediating chains which have the effect of both facilitating acquisition and transfer performance (Jenkins, 1963). It would seem that the effect, negative or positive, of supplementary color cues upon acquiring responses to associated shape cues may be a function of instructional stimuli and subsequent implicit or overt practice behavior of S.

Supplementary color cues are most frequently found in materials prepared for children. However, most of the evidence, regarding the facilitating effect of instructions upon conditioning elements of compound stimuli has been obtained with adult Ss. There is some evidence that characteristics of adult behavior with respect to effects of instructional stimuli can not be readily generalized to children. For example, Kausler, Laughlin & Trapp, (1963) found that incentive instructions to children had a markedly different effect upon the conditioning of incidental stimuli from that reported by Bahrick (1958) in a similar experiment with adult Ss. Tasks in which adult Ss routinely seem to employ implicit mediational responses were performed by children in ways that have not suggested such mediational behavior (Suppes & Ginsberg, 1961; Kendler & Kendler, 1959; Bruner, 1966; Osler & Trautman, 1961). Thus if mediational responses are required to insure facilitating effects of supplementary relevant cues, and if these responses are relatively unavailable to children, it would follow that the addition of such supplementary cues to stimulus displays would not facilitate learning by children.

It was the purpose of the following experiments to investigate the effects on the behavior of children in a shape labeling task, of varying the relevance of supplementary color cues and the nature of the orienting instructions and tasks.

EXPERIMENT I

When presented with a compound stimulus consisting of a highly meaningful and relevant color component and a trigram of low rated meaningfulness, adult Ss readily conditioned responses to the color component while evidencing no concurrent conditioning to the trigram (Underwood, Ham & Ekstrand, 1962). It was argued that cue selection had interfered with the conditioning of the trigram alone. If, however, cues were conditioned in a more direct fashion without biased cue selection behavior such that both color cues and trigram were conditioned there would not be a basis for interference in acquiring the trigram. There is some evidence that children do tend to condition cues in a relatively non-selective way. The Osler & Trautman (1961) and Kausler, et. al. (1963) have both interpreted their findings in a way that would suggest that cue selection behavior may be less evident in children than in adults.

It was the purpose of the present study to examine further the cue selection phenomenon by extending the investigation to children. In the first experiment the relevance of the incidental color component in compound shape and color stimuli was varied independently in both acquisition and transfer trials.

Method

Construction of stimuli and apparatus: Six shapes were constructed by reducing the complexity of contour detail and roughly equating the total area of six countries chosen for their relative similarity of shape and degree of unfamiliarity to fourth graders. The countries were Bulgaria, Equador, Poland, Romania, Surinam and Egypt. Directional orientation of the figures was determined arbitrarily to further reduce the probability of any effects of previous learning. The resulting contour shapes are represented in Fig. 1. These modified map contours were traced onto colored Prang construction paper so that each contour was represented on red, yellow, violet, blue, dark green and light brown paper. The six colored versions of each map and the corresponding six printed country names were then separately mounted on white mounting board and photographed with Kodachrome film. The resulting slides were then positioned in a Sarkes-Tarzian random access projector which was equipped with an auxiliary timer set to yield trials consisting of a 3 sec. exposure of the projected map, 3 sec. anticipation interval, 3 sec. exposure of the country name and a 3 sec. unfilled intertrial interval. The slides were projected on a 12 in. square rear-view screen positioned 30 in. directly in front of the seated S. The screen formed part of a visual barrier separating S from E and the experimental apparatus. The screen image of the projected maps averaged 8 in. in height and width.

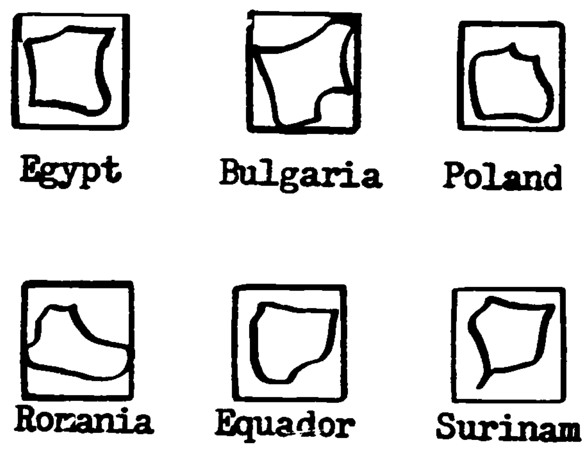

Fig. 1. Shape components of stimulus figures with associated response terms.

Procedure: S was seated before the screen and told that he would learn to identify several countries. Complete instructions are in Appendix A. A printed card showing each of the country names was given to S, and he was asked to read the names from a card. Any reading error was corrected. S was instructed to say aloud the name of each country during the anticipation interval. The six shapes were presented in successive random permutations with the restriction that no shape was presented twice in succession.

There were three independent training conditions. In the relevant-redundant (RR) condition Egypt was red, Bulgaria green, Poland yellow, Romania blue, Equador brown and Surinam violet on each trial. In the irrelevant-independent (II) condition the 36 possible shape-color combinations were assigned randomly to each

set of six trials with the above noted restriction on shape permutations. In the irrelevant-redundant (IR) condition all contour maps were represented in red on all trials. See Appendix B for a more detailed summary of the stimulus display.

Training continued until S completed two consecutive trials without an anticipation error. The eight Ss from each of the three conditions of color relevance in training were randomly divided into two groups of four and assigned the two remaining color relevance conditions. Training continued without interruption until the criterion of two errorless trials was again attained. This design resulted in six training-transfer combinations.

Subjects: Ss were 24 fourth grade students from a single classroom of the Indiana University Elementary School. Four Ss were assigned on a random basis to each of the six experimental conditions.

Results and discussion: Errors were tabulated on training trials and transfer trials separately (Appendix C). Means for each condition of color relevance on training and transfer are shown graphically in Fig. 2. Mean of errors on training trials for group trained with the RR condition was 20.25, the IR was 31.62 and with II was 55.13. These means differed significantly, $F(2,21)=4.34$, $p<.05$. The Newman-Keuls (Weiner, 1962) interval test indicated that while RR and IR did not differ significantly in training both RR and IR differed significantly from II, $p<.01$.

On the transfer tasks, the mean number of errors for the six training-transfer conditions differed significantly in errors on the transfer task, $F(5,18)=5.18$, $p<.01$. The mean number of errors during transfer for the RR-II group was significantly greater than for any of the other groups, Neuman-Keuls, $p<.01$, while the other groups did not differ from each other significantly.

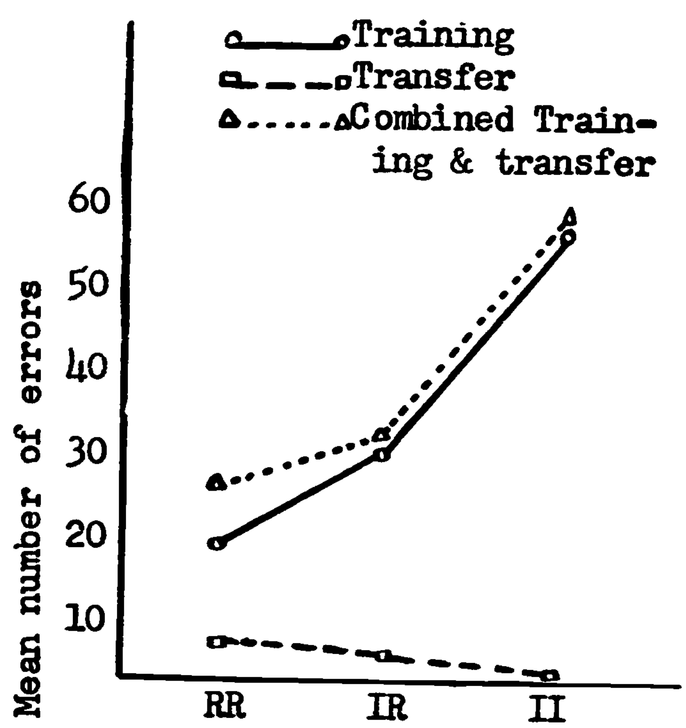

Fig. 2. Mean errors on training and transfer and combined training and transfer for three color relevant conditions. Exp. I.

Although the mean difference between the RR and IR groups did not reach significance during training, the analysis of the transfer results indicated a significant difference between the RR-II and all other transfer groups including the IR-II group. If responses were conditioned to the relevant color cues in the RR training condition, then interference with performance in the transfer task that included the noisy color cue condition of the II transfer condition would be expected. If the RR training condition had been characterized by cue selection of the highly meaningful color cues with correspondingly decreased conditioning of the shape cues, then the RR-IR transfer condition would have been expected to be associated with an increased error rate when compared with transfer performance following IR or II training. The failure to obtain such a difference between the RR-IR transfer condition and any of the other transfer conditions, except the RR-II condition, is not consistent with the prediction of cue selection affected by relative meaningfulness (Underwood, 1964).

Both training and transfer data lend support to the conclusion that both shape and color cues were conditioned in the RR training condition, with no evidence of interference with the shape cue conditioning as a function of the accompanying color cue conditioning. While the supplementary relevant color cues present during training did not significantly facilitate or interfere with conditioning of shape cues during training trials, their effect became evident in transfer. When transfered to the noisy color condition (II), the group for which color had been previously relevant (RR) suffered an interfering effect; the group for which color had not been previously relevant (IR) continued to respond to the shape cues and was functionally unaffected by the presence of irrelevant color cues in the transfer task.

While supplementary color cues had demonstrable effects in this experiment during both training and transfer, there was no evidence of a facilitating effect on the acquisition of responses to the shape cues. The data seem most consistent with the assumption that associations were formed in a direct, non-mediated way between all relevant cues and reinforced responses. This finding is consistent with the assumption that younger children may make more direct associations while adults tend to employ more complex mediational or symbolic procedures in learning tasks such as this. Another interpretation of the findings suggested by overtraining effect on conditions of compound stimuli reported by James & Greeno (1966) is that since the instructions mentioned maps and did not refer to color, that selection of shape cues occurred and that the relatively easily conditioned color cues were conditioned afterward during the two criterion or overtraining trials. Such a sequence of events would not result in reducing the training trials when compared with IR training and could result in

some relative interference when Ss were later confronted with the II set of stimuli. Instructions alerting S to the potential facilitating function of the color component may increase the possibility that if color components are conditioned rapidly they might serve as prompting or mediating stimuli and thus facilitate the conditioning of the shape component. Such a procedure would provide a basis for facilitation of shape condition by adding supplementary relevant color cues. Facilitation would be expected both during training and transfer to a shape-only condition. In a variety of tasks involving children, instructions (Osler & Weiss, 1962) and equivalent practice procedures (Suppes & Ginsberg, 1961; Olsen, 1966) have had effects interpreted as indicating an increase in the frequency of complex mediational behavior in comparison to the more direct association process apparent in uninstructed groups.

EXPERIMENT II

It was the purpose of the second experiment to determine the effects of instructions regarding the relevance of supplementary color under conditions that differed with respect to the formal relevance of color in training and transfer. Responses required during practice were also varied with respect to the probability of vocally emitting mediational responses.

Procedure: Ss were 72 fourth grade students from Indiana University Elementary School and were assigned randomly to each of the twelve practice conditions in a 3 x 2 x 2 factorial design such that there were six Ss in each group. The three conditions of color relevance were relevant redundant (RR), independent redundant (IR) and irrelevant independent (II) and were defined with the same set of stimuli used in Experiment I. The two instructional conditions differed in that the observe-color (O) group was instructed that "color may help you remember the letter that goes with each map", and the ignore-color group (I) was instructed that the label for each map should be learned "without depending upon the color of the maps". The third factor was the behavior required during practice. One group (R) was instructed to repeat vocally the initial letter of the country name at approximately 1 sec. intervals during the presentation of the map stimulus. The other group (S) was instructed to state vocally during the presentation of the map stimulus "anything that helps you remember which letter goes with the map". (Complete instructions are presented in Appendix D)

The stimulus materials were the same as those used in Experiment I except that the Egypt stimulus was reserved for use as a sample stimulus presented only during instructions. Multiple copies of the five remaining map slides and associated name slides

were ordered in the Kodak Carousel projector in random permutations of the five pairs of maps and names. The country names were printed on a card that was taped to the desk top where S sat, and was instructed that these were the names of the countries he was to learn to identify, but that he needed only to say the initial letter of the country name during the experiment.

During practice trials the projected name of a country was presented for 1 sec. followed by a 10 sec. presentation of a projected map. During the map presentation interval the R and S groups practiced as instructed. Following the completion of each practice trial, consisting of a serial presentation of the five name and map pairs, a test trial occurred, consisting of a presentation of each map for an S controlled interval of up to 10 sec. that was terminated when he uttered one of the initial letters. No information feedback occurred on test trials.

Alternating practice and test trials continued until a criterion of two errorless test trials was reached. When the first criterion of two errorless trials was attained, either the same or one of the other two sets of stimulus slides defining one of the three conditions of color relevance was substituted for the training stimulus set, and training continued without further instructions until two consecutive errorless trials was again attained.

Verbatum practice and test responses were recorded by E. Ss were assigned randomly with the restriction that there be an equal number in each of the thirty-six cells resulting from combining orthogonally the 3 x 2 x 2 training design with the three conditions of color relevance (RR, IR, II) introduced in the transfer task.

Method and Discussion

Errors were totaled for both training and transfer tasks separately (Appendix E), and an analysis of variance of training, transfer and combined training and transfer errors was completed (Appendix F). The mean number of errors associated with the RR condition was 8.96 which was well below the mean of 21.33 errors for IR and 23.04 for II. These means differed significantly,

TABLE 1. MEANS AND SD'S OF TOTAL ERRORS FOR EACH COMBINATION OF COLOR RELEVANCE, INSTRUCTIONAL COLOR REFERENCE AND PRACTICE CONDITION, EXPERIMENT II

Relevance of color component	Observe Color				Ignore Color			
	Repeat		Strategy		Repeat		Strategy	
	M	SD	M	SD	M	SD	M	SD
II	39.00	16.16	26.67	19.21	8.67	4.35	17.83	13.90
IR	25.00	11.27	18.33	11.37	20.00	15.05	21.50	16.74
RR	9.67	3.68	8.67	6.90	8.33	4.46	9.17	6.26

$F(2,60)=8.21$, $p<.01$. The Neuman-Keuls interval test indicated that the substantially lower error rate associated with the RR condition differed significantly from those of the IR and II conditions, $p<.01$. Although the IR and II conditions did not differ significantly with respect to mean errors, a significant interaction between color relevance and instructions regarding color was obtained, $F(1,60)=5.19$, $p<.05$, which must be considered in making the comparison. As illustrated in Fig. 3, the difference in instructions to ignore or observe color was associated with a significant difference only in the II stimulus condition, Neuman Keuls, $p<.01$. In the II condition the mean error score for the group instructed to observe color was 32.84 while it was only 13.25 for the group instructed to ignore color.

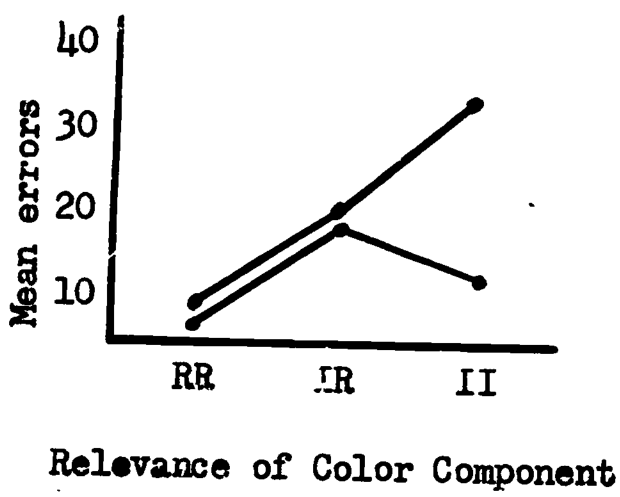

Fig. 3. Mean errors on training task as a function of relevance of color component of shape-color compound stimulus.

Although the general trend of difference between color relevance conditions was in the direction of those found in Experiment I, the interval test showed that with respect to the shape only (IR) control condition, the color relevant (RR) condition was associated with significantly fewer errors in Experiment II but not in Experiment I. In addition, while there had been a significant difference between IR and II in Experiment I, II was not uniformly interfering in Experiment II. The

transfer results were very similar to the results obtained in Experiment I. The mean number of errors on the transfer conditions was one or less for all groups that had been originally trained with II and IR stimulus sets. Only in the case of the groups originally trained with color relevant (RR) and transfered to a condition in which color was not relevant was the error rate significantly elevated, $F(2,36)=5.29$ $p<.01$. An interval test revealed that both the RR-IR and the RR-II conditions differed significantly from the other groups. The interference indicated by the significant RR-IR error rate in transfer was not observed in Experiment I. Thus in the absence of a difference in Experiment I between IR and RR during training and between RR-IR and IR-RR or IR-IR in transfer, a possible conclusion was that cue selection had not occurred. The corresponding results in Experiment II make such an interpretation more difficult to defend. Either a cue selection or a differential threshold interpretation could account for the experimental findings. The relative high judged meaningfulness of the color cues may have made it possible for the threshold, for reliably emitting responses to color cues, to have been reached before all shape cues had been conditioned. Such an interpretation would account for the differences obtained in Experiment II in both training and transfer results involving the group initially trained with RR stimuli. The absence of significant differences for corresponding groups in Experiment I does not seriously weaken such an interpretation since in both training and transfer in Experiment I the corresponding differences, although not significant, were in the same direction as those obtained in Experiment II. The various differences in procedure between the two experiments could have combined to yield the difference in level of significance obtained without requiring additional assumptions of cue selection.

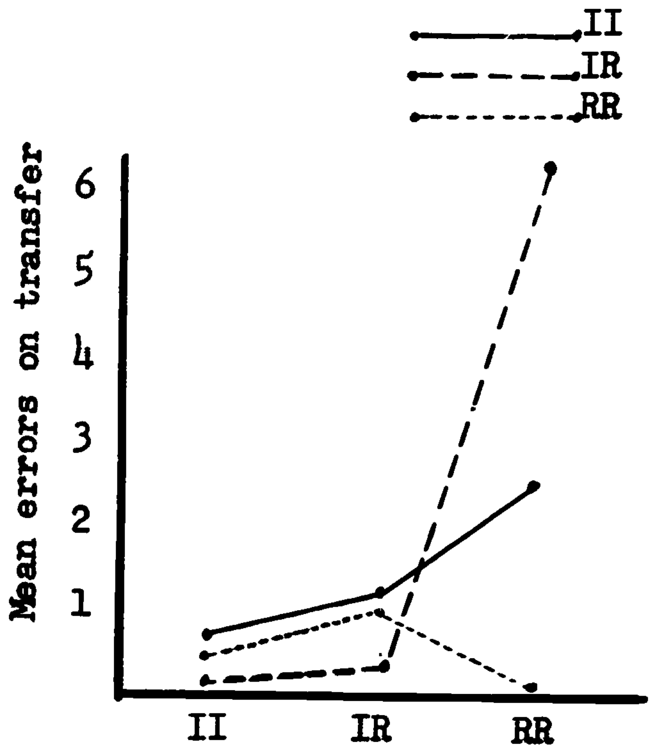

Fig. 4. Errors on transfer for each combination of color relevance during training and transfer, Experiment II.

However, without making further assumption, neither this interpretation nor a cue selection interpretation, with bias favoring the more meaningful color cues, is consistent with the

results of the comparison of the combined training and transfer results. The means of combined errors on both training and transfer for the color cue training conditions was 11.83 errors for RR, 22.12 for IR and 23.27 for II which differed significantly, $F(2,36)=7.47$, p .01, with an interval test showing that RR differed ($p < .01$) from both IR and II which did not differ significantly from each other. Cue selection during training, biased toward the more meaningful color cues, would have resulted in combining the errors associated with forming the color associations during training with the errors required in establishing the shape association in the transfer tasks. These combined errors should have been more than those incurred by the group trained with shape alone (IR) from the beginning. Unbiased conditioning of both sets of relevant cues should have required as many trials for RR as for IR since the final criterion in both cases required transfer performance with IR alone; and under the assumption of unbiased conditioning, the conditioning of shape cues in the RR condition procedes independently of the conditioning of the associated relevant color cues. Furthermore, because of the procedures used, there is little support for an interpretation of the finding of sizable facilitation associated with the RR condition which would posit a prompting effect of relevant color made possible by the early conditioning of the color components, thus making the response term more available during anticipation. In the procedures employed in this experiment there was no anticipation interval during training. An anticipation interval was available during the test sequences, but since it was S controlled it seems highly unlikely that, after he had made the correct anticipation by refering only to the color component, S would have engaged in the kind of precursory behavior alluded to by Holland (1966) as being required to insure the establishment of associations to shape cues.

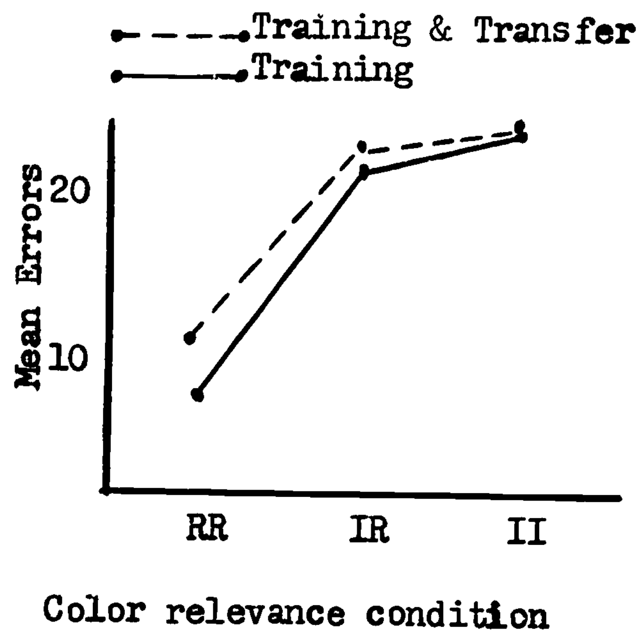

Fig. 5. Mean errors on training and training plus transfer for stimulus conditions of color relevant and redundant (RR), irrelevant and redundant (IR) and irrelevant and independent (II), Experiment II

The verbal responses emitted during anticipation trials give little indication regarding the effect of the color cues.

There was no difference in error rate associated with the two practice conditions. In the content analysis of the emitted responses of the strategy group there were only rare and unreliable references to color cues. References tended to be single word or short phrase responses apparently elicited by shape alone and including such words as "shoe", "flag" and "arrow". These references tended to appear in all protocols regardless of color condition, by the second practice trial and were relatively invariant over the remaining trials. These responses suggest that the shape cues were discriminated readily and reliably by the second trials and that formal differentiation of the shapes after the first trial was established and apparently not enhanced by the available color cues. While shapes could be reliably discriminated and labeled with highly meaningful labels, it may be that the color condition affected the frequency of non-discriminating responses. Color cues have been demonstrated to be highly dominant cues for children, and since reliably discriminating color cues were available only in the RR condition, considerable interference as a function of color, may have occurred in both the IR and the II conditions. However, the fact that significant differences between groups instructed to ignore or to observe color resulted in marked differences in performance for the II condition and not for the IR condition could lead to interpretations that: selectively ignoring the color cues followed appropriate instructions to the II groups; that corresponding instructions to the IR group were redundant, since instructions to ignore the irrelevant color cues resulted in the same performance on both training and transfer as instructions to observe them. If both the IR groups and the II group, receiving appropriate instructions, did effectively avoid potentially interfering responses to irrelevant color cues, then the relatively lower error rate of the RR groups must be accounted for by a facilitating effect of relevant color cues in RR rather than by the interfering effect of irrelevant color cues in IR and II.

The establishment of a mediational chain, linking first the color cues to the responses and finally the shape cues to the color cues, would provide a basis for facilitation by the supplementary color relevant cues. Instructions suggesting the relevance of color may have increased the probability of such chaining; whereas in the absence of such instructions regarding color, (as in Experiment I) Ss may have either relaxed any selective processes or delayed color conditioning until after shape cues had been first conditioned. In either case facilitation of shape association as a function of color association found during training (or combined training and transfer) would not have been expected.

Although color cues present in compound stimuli tend to be functionally dominant for both children (Bruner) and adults (Grant), it is clear that in many tasks, adults tend to avoid categorizing or responding selectively to color cues unless

instructions clearly establish the relevance of color. This response bias may be sufficiently established by the fourth grade to have made possible the differences in facilitation associated with the presence of relevant color. However, any reference in the instructions to the possible relevance of color, including even the suggestion that the task should be accomplished "without depending upon color" seems to have been sufficient to significantly alter the mode of response to the color cues present. The effect of these instructions was apparently a function of the objective relevance of color in the task such that, in the case of RR, color was facilitating and that, in the case of II, the potentially interfering effects of irrelevant color were avoided.

Although the gross differences in overt practice response between the S and R groups were not significant, there were qualitative differences between the utterances of the rapid learners in the S group and the slower learners. The rapid learners produced responses that could be readily associated with both the stimulus shape and the response term. For example, a common response by the slower learners to the map associated with Romania was "shoe", by the more rapid learners -- "rubber boot". The few Ss that produced such vague and general responses as "shape" or "color" had the greatest number of errors in learning the task. If S was employing a complex learning strategy involving color cues, there was no direct indication of it in either the responses emitted on practice trials nor in the post-experimental inquiry. In the case of both S and R practice conditions, when asked how they learned to remember the items, almost all Ss in all conditions indicated that they remembered the item because it looked like some familiar object.

The kind of overt responses emitted during practice were not controlled in the present experiment and seemed to have served as highly effective mediating responses in some cases. If association could be greatly enhanced by suggesting highly meaningful mediating responses to S which could be readily associated with both shape component of the stimulus term and the response term independently of the color component present, it seems that both relevant and irrelevant color cues would be expected to be relatively ineffective. If S were forced to attend to the color component by the additional requirement of a color orienting response during practice, the effect would seem to depend upon the relevance of color and the relevance of the shape association term.

EXPERIMENT III

If the facilitating effect of color depended upon the establishment of a mediational chain involving color, then it would seem that the availability of relevant color cues would be: most helpful when the available mediating responses associated with shape cues are most difficult to associate with the response term; of little or no help when the mediating response to shape is initially highly associated with the response term.

The Experiment II data can be interpreted in terms of an assumed establishment of a mediational chain involving color-associated mediating terms. The overt practice responses by the S groups revealed that the emission of shape-associated mediators, which were also highly associated with the response terms, greatly facilitated learning. The design of Experiment II was such that it could not be determined whether the selection of these highly efficient shape-related mediators interfered with any interfering or facilitating effects associated with the color component of the stimuli. If children are capable of making highly selective responses to the shape or color component as a function of instructions or formal relevance of the color component, then it would seem that they might also make selective responses as a function of the effectiveness of the shape-related mediator. If mediational activity depends heavily upon instructions to mediate, as suggested by Jenkins (1963), and if alternative and easier mediational chains are available, it seems that the law of least effort would require that the color mediators would not be used. If learning in this case is to be accounted for entirely in terms of mediating events, it would seem that the formal relevance of the color components of the compound stimuli should have no effect under conditions of optimal effectiveness and availability of shape-related mediating terms. It was the purpose of Experiment III to investigate the above hypothesis over a range of two degrees of response-relatedness of a set of mediating terms that were all readily associated with the shape components. It was of particular interest to investigate the interaction of this effect with the effect of varying the formal relevance of the color component of the compound stimulus.

Method

Subjects: Sixty-four fourth graders and 32 third graders from the Indiana University Elementary School served as Ss. They were randomly assigned to experimental conditions with the restriction that 8 fourth graders and 4 third graders were assigned to each cell of the 2 x 2 x 2 factorial design. Children were initially screened for ability to name correctly some circular samples of color similar to those used in the stimulus material. None was rejected due to inability to do so.

Design and procedure: Alternating prompted practice and test trials with the same corresponding time intervals were used as in Experiment II. In addition, the two conditions of color relevance were defined by using the RR and II sets of stimuli used in Experiments I and II. Two conditions of color orienting instructions were defined by instructions to one group to name the color of the map on each frame (N) and to a second group not to name the colors ($\bar{N}$). The third factor was defined by two sets of shape-related terms which differed in that each term in one set (I) had the same initial letter as the required response term, whereas no term in the second set ($\bar{I}$) had an initial letter which was included in the list of response terms. Complete instructions are found in Appendix G. The I list of terms, with associated response terms were: ear-E, rubber boot-R, banner-B, patch-P, and spear-S. The corresponding $\bar{I}$ list contained the following terms with their associated response terms: mitten-E, overshoe-R, flag-B, lake-P and arrowhead-S. Items from both lists had been taken from the practice protocols of Ss in the S group of Experiment II where each term had been reliably and readily associated with the appropriate map stimulus.

S was presented a printed list of the response-related terms associated with his assigned experimental condition and was instructed to read and define each term, being prompted by E in the rare cases of difficulty. He was instructed that these terms were to be used as "clues" and that each term was to be repeated twice on every practice trial during the presentation of the appropriate map. An illustration of the required practice response, employing such a clue word, was presented verbally by E, explaining that if the map to be learned were that of Mexico, the clue might be the word banana. It was pointed out that a banana was curved like the map of Mexico is. S was prompted on practice trials for the first two trials by hearing the appropriate clue word stated by E if he had not volunteered it after approximately 2 sec. Ss rarely required more than one prompt to associate the practice term with the appropriate map stimulus. In addition, as part of the clue instruction those Ss in the N condition were instructed on practice trials to name the color of the map as part of the clue. Thus the practice response illustrated by E for the N group while viewing the green map of Mexico was "M -- green banana, M -- green banana"; while for the $\bar{N}$ group it was "M -- banana, M -- banana".

The required practice procedure was followed without difficulty by all Ss, throughout the experiment.

Results

Errors were tabulated for each experimental group and are reported in Appendix H. A summary of the results of an analysis

of variance is reported in Appendix I. Although the means for the third and fourth grades were 27.72 and 19.68 errors respectively and differed significantly, $F(1,87)=8.12$, $p<.01$, there was no significant interactions between grade level and other conditions. Therefore, the scores of the two grade level groups were pooled. The resulting means and SDs for each experimental group are reported in Table 2 and Fig. 6. It was evident that the attempt

TABLE 2. MEANS AND SD'S OF ERRORS TO CRITERION AS A FUNCTION OF SHAPE AND COLOR NAMING PRACTICE CONDITIONS AND COLOR RELEVANCE CONDITIONS.

Color Relevance	Orienting Task Responses							
	Not Name Color				Name Color			
	Initial letter		Non-Ini. ltr.		Ini. ltr.		Non-Ini. ltr.	
	M	SD	M	SD	M	SD	M	SD
RR	6.08	5.87	22.58	17.55	11.59	5.28	23.50	15.20
II	9.83	8.50	31.92	17.44	18.92	10.41	53.33	18.03

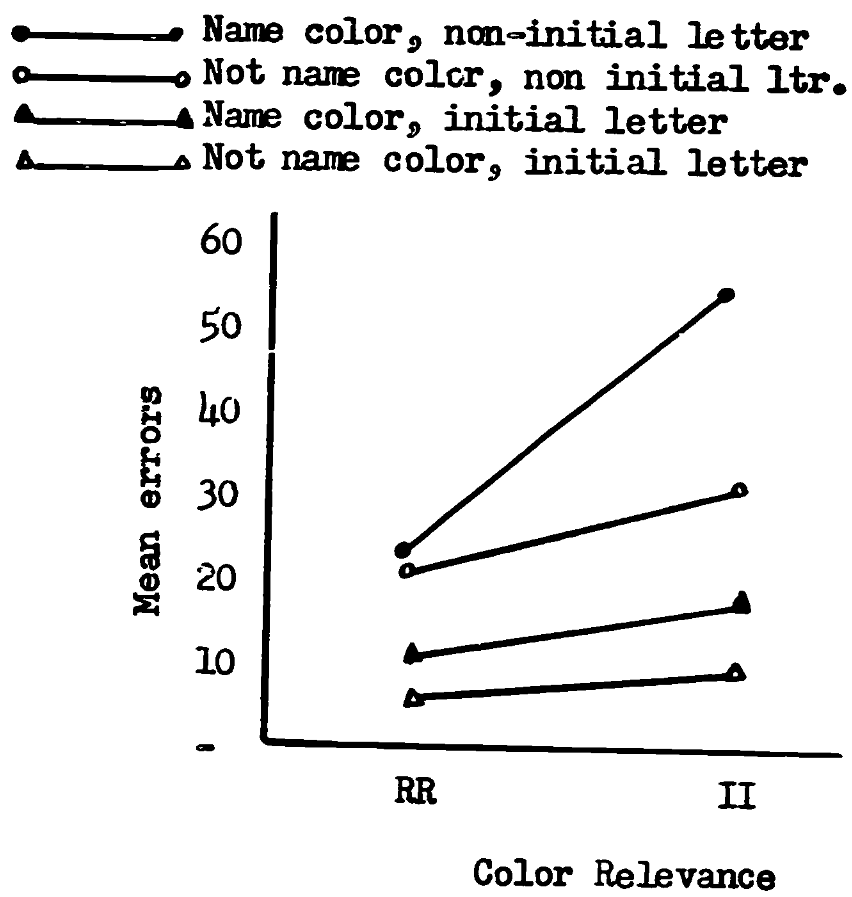

Fig. 6. Mean errors for color and shape naming condition as a function of color relevance

to establish wide differences in error rate between the two conditions of shape related orienting tasks was successful. The overall mean for the I condition was 32.93 errors and differed significantly from that of the $\bar{I}$ condition which was 11.53 errors, $F(1,87)=60.81$, $p<.001$. Relevance of color, $F(1,87)=21.18$, $p<.01$ and naming color, $F(1,87)=11.51$, $p<.01$ were also significant factors. As in previous studies relevant color was associated with fewer errors than irrelevant independent color. The interfering effect of II was greater when color naming was required, $F(1,87)=4.85$, $p<.05$ and when the less effective shape-related practice response ($\bar{I}$) was required, $F(1,87)=6.60$, $p<.05$.

The introduction during practice trials of an orienting task that was readily related to both shape cues and the response term did not eliminate the effect of relevant color cues present in the compound stimulus. The Neuman-Keuls interval test indicated significant differences between II and RR even under the most favorable shape-related orienting task conditions, $p<.05$. This difference may have remained due to the selection of color cues in spite of specific instructions regarding the relevance of the shape orienting responses and the absence of reference to color in the $\bar{N}$ groups. However, the reference to color in the initial screening test may have been sufficient to sensitize the Ss to the possible relevance of color, just as the negative instructions regarding color in Experiment II seemed to have sensitized the RR groups to the relevance of color.

Discussion of Experiments I, II and III.

In all three experiments, involving children averaging 10 years of age, evidence has been obtained concerning the effect of varying the relevance of the color component of a compound stimulus. This effect has also been shown to be a function of instructions and practice conditions. Some degree of color cue selection seems to occur, particularly if both instructions and stimulus array provide consistent information regarding color relevance. Color cue selection in Experiment II seemed to be associated with the conditioning of shape cues in such a way as to facilitate combined training and transfer performance. This behavior seemed to be somewhat in contrast with the apparent independent associations to shape and color cues formed in Experiment I under instructional and practice conditions that provided no information regarding the relevance of color cues. If the color cues were facilitating only because they provided a mediating link between the shape stimulus and the response term, it seemed that the procedure of providing S with such a mediator that was not associated with the color component would eliminate the effect of the color cues present. It was found, in Experiment III that the effectiveness of the color cues was reduced but not eliminated under such practice conditions.

It seems, in summary, that while instructions to use the color cues in an appropriate way can both increase the positive effect of relevant cues and reduce the interfering effect of irrelevant cues, there is reason to believe that there is a residual effect that is not entirely displaced by these procedures. Its characteristics are such that the most parsimoneous set of assumptions seems to require that some stimulus sampling of available color cues continues through training. Instructions regarding the relevance of other sets of cues do not eliminate the continuing effectiveness of these cues during training. The effectiveness of color relevance seems to be generally proportional to the length of training required. When instructions and procedures are such that shape cues are conditioned slowly, the relative effect of associated color cues seems greater. This suggests that the effect is present over trials and not only after initial criterion is reached, as was found with adults by James and Greeno (1966). Thus, behavior resulting in the selection of only color or shape cues exclusively may be only partially established in 10 year-olds although possibly evident in adults.

Conclusions, Implication and Recommendations

If color cues are added to a stimulus array with the expectation that they have a facilitating effect upon the acquisition of associations to the shape component, then it appears that active intervention by presenting appropriate instructions and practice procedures may be required. The data suggest that such procedures significantly affect stimulus sampling and may have an additional effect upon the development of mediational chains.

The findings of these three experiments have several implications for further research and developmental activity. One question concerns the possible generality of these findings to tasks involving other types of compound stimuli. Instructional displays are typically compound, consisting usually of various visual, auditory and other elements of varying degrees of relevance to the learning task required. The class of stimuli studied in the present series of experiments consisted of intrinsically associated components. In the intrinsically associated class of stimuli, orienting responses which result in the sensory reception of one stimulus component insure the reception of the other component(s). It may be that the apparent difficulty of children in sampling from only one set of cues may be a function of the special characteristics of intrinsically associated stimuli such as were used in this experiment. It is clear that non-mediating organisms come to respond selectively to elements of compound stimuli by inhibiting or adapting some of the elements. It has also been observed that orienting responses may change the probability of sampling from one or more of the cue sub-sets. However, the orienting response is not effective in differentialy changing the sensory input of

components of an intrinsically associated stimulus. If the only alternative is to undergo a relatively lengthy and unpleasant process of adapting irrelevant cues, then the case of the intrinsically associated stimulus poses a very difficult challenge to efficient learning. That selectivity is possible, if not routine, in the case of intrinsically associated stimuli is suggested by Mechanic's (1962) demonstration of the need for appropriate orienting tasks to insure that adults make appropriate responses to both components of such stimuli.

An attempt to design instructional procedures that make optimal use of supplementary stimulus components is complicated by the possibility that procedures which are optimal for children are interfering for adults and conversely. It may also be that compound stimulus materials which are intrinsically associated require different procedures for optimal utilization than those which are discretely associated.

The second part of this series of studies attempted to investigate certain effects of color relevance with adult Ss.

EXPERIMENT IV

It was noted that in the first three experiments evidence of the effectiveness of variation in color relevance was obtained under instructional conditions that were contrived to indicate that color was either not relevant, or that stated alternative cues were available in lieu of color. In both cases, however, color was apparently effective. It could be argued that children are effectively unable to ignore color, even when they are actively responding to other cues. An alternative argument is that mediational behavior was affected by the stimulus conditions of the training and test sequence, and that the initial verbal instructions were modified according to these task characteristics. In each of the earlier experiments the stimuli present on the test trial were drawn from the same color condition as were the training stimuli. This would provide the basis for confirmation or disconfirmation, on the first test trial, of the validity of the initial instructions regarding the relevance of the color cues. Thus, it would seem that the effect of supplementary color on training trials depends upon the color condition present on the test trials independently of the condition on the training trials.

Another possibility is that color cues were sampled selectively on trials in which shape cues did not provide a basis for forming discriminations. Poulson, Restle and Poulson (1965) have presented evidence that indicates a two step learning process in the case of learning paired-associate

responses to highly confusable shapes. A discrimination step, in addition to an association step, seems to have been required. It seems possible that relevant color may affect the discrimination step and not the association step. If this discrimination step were facilitated by the presence of associated color cues, then relevant color might be expected to facilitate the acquisition of highly confusable stimuli but not to facilitate the acquisition of readily discriminable stimuli.

It was the purpose of this experiment to investigate the effects of varying the relevance of color independently in training and test trials, and of varying the discriminability of associated shape components under those instructional conditions which indicate that color is not relevant. The length of the anticipation interval during training trials was also varied. If it is assumed that discrimination typically precedes association and that discrimination may be facilitated by the association between the shape and color components, it seems possible that extending the anticipation interval prior to the information feedback event would facilitate the formation of such discriminations.

Method

Subjects and design: The 215 Ss were from summer session graduate and undergraduate classes in education. The population sampled was relatively heterogeneous with respect to age and nationality. Data from thirty-five Ss were omitted from the final analysis because of procedural and apparatus irregularities. The three training conditions, two test conditions, and two interval conditions resulted in a 3 x 2 x 2 factorial design with repeated measures of the paired and non-paired stimulus sets. Two cells were filled by substitution since transfer from IR to the same color relevance condition was logically identical with transfer to the identical condition used in training. In the final analysis of the data the 36 Ss trained under the IR to IR conditions were used for both S_t and IR_t transfer cells.

Stimulus materials: Eight simplified line drawings that had been used by Poulson, Restle, and Poulson (1965) served as the shape component of the stimulus set. Figures representing an apple, a hat, a trefoil and the knight chess piece were readily discriminable from all other shapes, while two figures representing leaves differed only slightly, and two figures representing diamond shapes also differed only slight. The first four figures were refered to as non-paired ($\bar{P}$) and the last four as paired (P). Response terms were the words part, hope, rush and only. Each term was matched arbitrarily with one of the four $\bar{P}$ figures. Similarly the same four terms were matched with the P figures and were lettered in black india ink immediately below the figures.

Each of the eight figures was rendered on eight very distinctive value of colored paper (Craftint papers; yellow, red, blue, green, brown, grey, orange and purple). The resulting 64 drawings were cut out and mounted on white background material and photographed on 35mm Ektachrome film. The resulting colors were somewhat distorted in color value but were readily discriminable. Multiple copies were produced so that five randomly ordered permutations could be successively ordered in the Carousel slide drum.

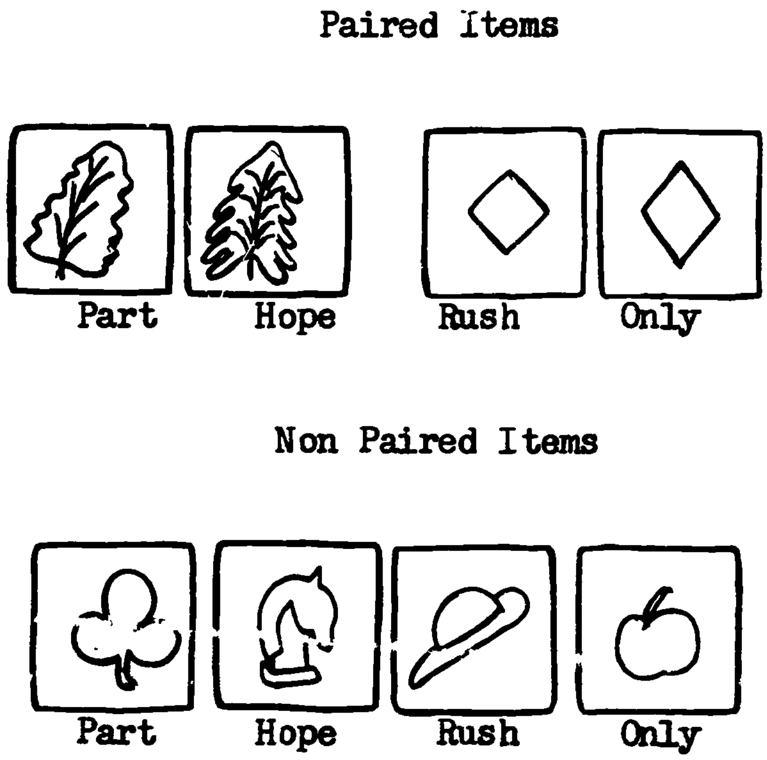

Fig. 7. Response words did not appear during test trials.

The three conditions of color relevance were defined as in the first three experiments. That is, in the relevant redundant (RR) condition, a given figure had a different color from each of the other eight figures and had that same color on each trial. In the irrelevant independent (II) color conditions varied independently of shape over trials. In the irrelevant redundant (IR) condition, the color for all figures on all trials was red.

Procedure: Each S was assigned by order of appearance to one of the three conditions of color relevance. These groups were orthogonally divided such that the test trial stimuli for a given S were from either the same (S_t) or the IR set (IR_t). This was mechanically arranged by using two projectors with one containing the training stimuli and the other the test stimuli and using auxiliary switching controls to accomplish the necessary switching. The third independently manipulated factor was the interval of time by which the stimulus term anticipated the response term during the training trials. In the anticipation (A) condition the stimulus term was presented for 4 sec. before a shutter opened exposing the response term for an additional 2 sec. In the non-anticipation ($\bar{A}$) condition there was no corresponding 4 sec. presentation of the stimulus term preceding the paired presentation of the stimulus and response terms. A 2 sec. intertrial interval was employed. Training proceeded with alternating test trials until the earlier criterion consisting of either two errorless trials or a total of 11 test rials, had occurred.

The instructional stimuli (Appendix J) indicated that "color will not always help you on test trials, and you should try to concentrate on the associated shapes and words." The A group was told that they would see the shape alone preceding the presentation of the paired shape and word. They were told to try to remember the associated word during the anticipation interval and to say it aloud if they remembered it.

Results

There were three types of errors recorded. On the paired items a response that could have been correct for the other members of the pair was considered a confusion error (C). All other responses were called non-confusion errors ($\bar{C}$), and failure to respond, omission (O). All three types of errors were possible for the paired items while only $\bar{C}$ and O were possible for the non-paired items. Means by error types and conditions are reported in Table 3.

TABLE 3. MEAN ERRORS OF ON PAIRED AND NON PAIRED ITEMS FOR ANTICIPATION INTERVAL AND COLOR RELEVANT CONDITIONS IN TRAINING AND TEST TRIALS.

Anticipation Interval	Color Relevance		Paired			Non-Paired		
	Training	Test	C	$\bar{C}$	O	C	$\bar{C}$	O
4 sec.	IR	IR	9.83	7.17	3.17		2.11	1.67
4 sec.	RR	RR	5.89	5.06	4.22		2.17	1.44
4 sec.	RR	IR	10.89	5.33	3.22		4.17	2.06
4 sec.	II	II	12.33	8.56	2.00		4.11	1.33
4 sec.	II	IR	9.78	7.39	3.11		2.89	1.00
0 sec.	IR	IR	9.67	4.50	2.50		3.22	1.33
0 sec.	RR	RR	4.33	5.17	3.11		2.00	.67
0 sec.	RR	IR	9.17	5.56	3.17		3.50	1.56
0 sec.	II	II	10.67	7.06	4.44		4.00	2.00
0 sec.	II	IR	9.06	7.83	2.67		3.22	1.56

Total errors for the paired and non-paired items was compared first. An average of 15.52 errors was associated with paired items while 4.60 was associated with the non-paired items, resulting in a substantial difference, $F(1,204)=1252.98$, $p < .001$. This made possible a test of color effects in a list including items with

markedly different discriminability. Although the absolute differences between the mean number of errors associated with the three training color conditions were small (IR, 22.61, RR, 22.06 and II, 26.25), they did differ significantly, $F(2,204)=5.35$, $p<.01$, in this experiment. Color relevance during training was associated with discriminability of cues, indicating that color condition was effective in the case of paired stimuli but not in the case of the non-paired items, $F(2,204)=9.74$, $p<.01$. Further analysis of the data, comparing each of the three types of paired and non-paired errors, indicated that for each type of error possible, the differences between color training conditions were significant (as indicated by an interval test) only when comparing the effects on confusion errors for paired errors, $F(8,816)=3.36$, $p<.001$. In this case the combination of RR on training trials and RR on test trials was associated with a significantly lower error rate than any of the other combinations. The specific comparison of difference in error rate between RR-RR and RR-IR reveals a ratio of errors of almost 2 to 1 favoring the RR-RR condition. This finding is consistent with the assumption that the cue relevance of color during training is modified by the relevance of cues during the practice trials. In the case of the RR-IR group, the initial instructions indicating that color would not help was sufficient to result in complete absence of evidence of response to those relevant cues, even in

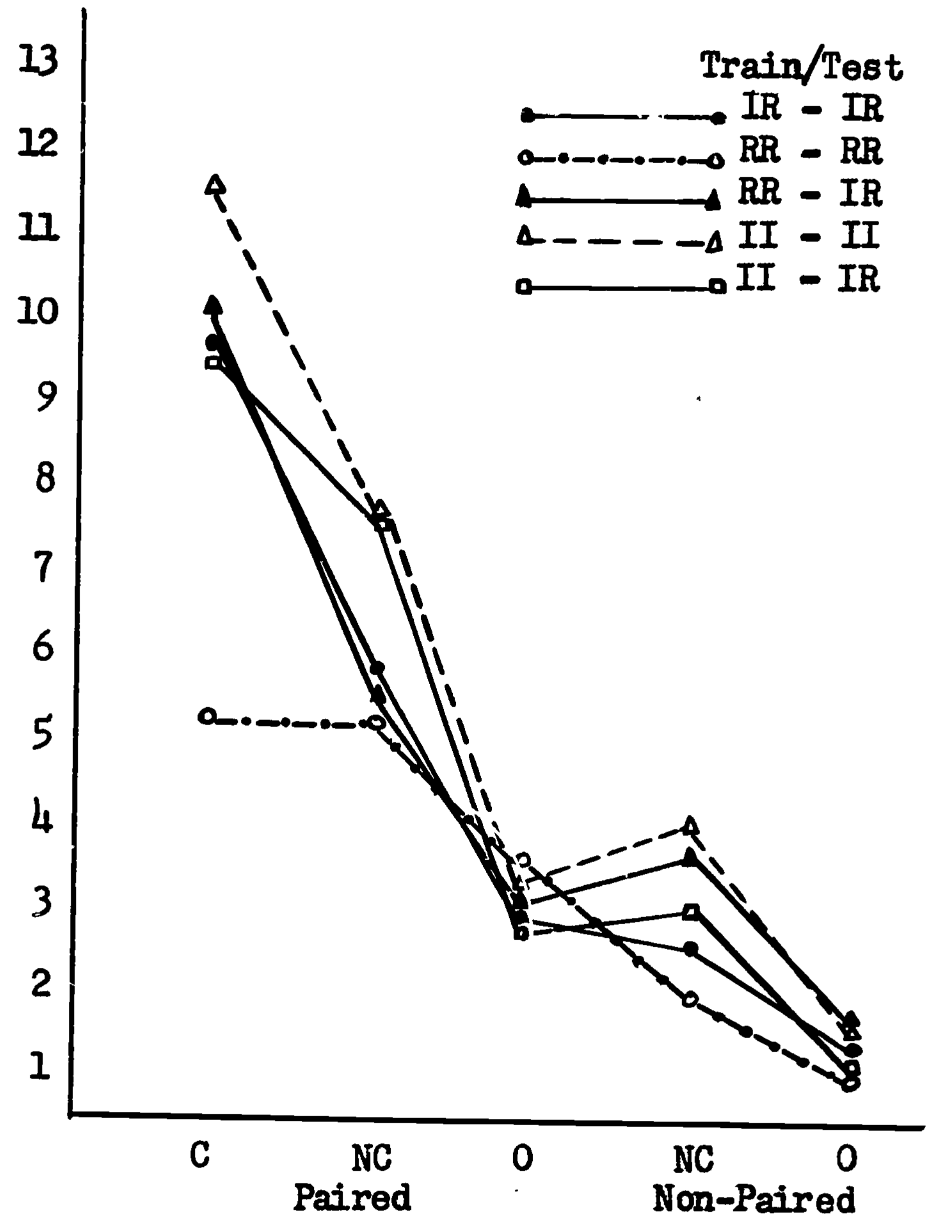

Fig. 8. Mean errors for groups differing in color relevance during training and test trials as a function of item type, Experiment IV.

the presence of stimuli that were exceedingly difficult to discriminate. The data are not sufficiently unambiguous to determine whether or not the relevant cues were used selectively with the paired items but not with the non-paired items. The absence of transfer data also precludes determining whether the selection of color cues competed with the selection of shape cues or had a facilitating effect.

The data did not uniformly support the assumptions regarding the possible facilitating effect of the extended anticipation interval. However, a significant interaction between anticipation effect and item type does indicate that the extended interval may have had a facilitating effect on the paired items, $F(1,204)=9.75$, $p<.01$. Since S was encouraged to anticipate overtly it may be that this overt behavior interfered somewhat with associations between color and shape that might have otherwise occurred.

The data in general indicate that adult Ss are capable of responding very selectively to color and may maintain selective biases that are inefficient if instructions and test procedures lead to such selective modes of responding.

EXPERIMENT V

Introduction

The specification of the behavioral effects of variations of color in visual displays has been an extremely important issue in the audio-visual field (Hoban and Van Ormer, 1950; Hoban, 1960; Travers, 1964). In spite of considerable research work the current situation seems aptly summed up by Dale's (1955, p. 353) observation that the educator has "precious little to draw on" in guiding his utilization of color in educational media. Even though preference for color, especially realistic color, has been consistently demonstrated there is little evidence available for a similarly

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Note -- Experiment V was written by Mr. Dan Lee Isaacs under the direction of Dr. Harvey B. Black as part of the requirements for a Master's Degree. This report appears on the following pages and is organized as an independent report. It does, however, follow Experiment IV sequentially, which is refered to as Black & Isaacs (1966) in the Experiment V report.

facilitating effect of color on learning. This failure to find a general facilitative effect has led to more analytic consideration of the potential effect of color. It has been suggested that color cues must be relevant, or must emphasize relevant cues (Miller, 1957), or help differentiate relevant cues (McGeoch and Irion, 1952), but certainly not draw the learner's attention away from the important cues (Hoban and Van Ormer, 1950).

Many laboratory studies have shown positive effects of supplementary color cues. Several studies (Peterson and Peterson, 1957; Saltz, 1963; Weiss and Margolius, 1954) utilizing words and trigrams have found that background color cues definitely facilitate acquisition of the primary stimulus. Similar data were found when variations in the color of stimulus figures were correlated with differences in responses in concept identification (Bourne and Restle, 1959), paired associate learning (Black, 1966), and search time (Green and Anderson, 1956). However, often of more practical importance than the problems of difficulty in acquisition of responses, is the probability of transferring a specific learned response to other stimuli or parts of the original stimuli. There is strong evidence available to support Hoban and Van Ormer's (1950) observation that in certain procedures there may be competitive and independent effects of color cues. Several studies (Underwood, Ham, and Ekstrand, 1962; Weiss and Margolius, 1954; Sundland and Wickens, 1962; and Black, 1966) have reported that when color cues that were relevant in training, were absent and the remaining cues tested with a transfer test there was a drop in performance. This drop was found to be inversely related to the meaningfulness of the set of shapes (Underwood, Ham, and Ekstrand, 1962). These findings suggest that if highly discriminable color cues were added to facilitate the learning of responses to easily confused, difficult, or low meaningfulness stimulus items, that the color cues would interfere with learning since the subject would tend to select the easier cues.

There is, however, a possibility that the apparent cue selection in the Underwood, Ham, and Ekstrand (1962) study was a function of the physical separation of color and other relevant cues used in that experiment. Therefore, one purpose of this study was to present stimuli in which the shape cues were not spatially separate from the color cues in order to determine whether cue selection would be observed when shape cues of the nominal stimulus were defined by the contours of the colored shape against the uniform background.

An additional question arose from a study by Black and Isaacs (1966) that yielded no evidence to support earlier findings that the presence of relevant color cues during training reduced training errors. The procedure used alerted the subjects to the requirements of the final test stimulus which did not include chromatic color cues. In addition, the subjects were

run a fixed number of trials and many of them did not learn all of the responses. One possibility that might account for the relevant cues not facilitating learning is that the subjects selected only the achromatic shape cues present. If this was the case it may have been a function of the early and repeated presentation of the achromatic criterion test stimuli or a function of the interrupted practice technique which may have facilitated the early conditioning of the easier shapes but cut short a phase of color conditioning which might occur later as the most difficult shapes were being learned. Therefore, the present study additionally attempts to investigate the possible sequential ordering of cue sampling by including an earlier and later test trial which respectively follow a less and more stringent criterion of performance.

In summary, the purpose of the present investigation was to observe the effects upon cue selection of variations in discriminability and difficulty of the primary cue set (shape), presence of relevant (color) cues, and the training level preceding test trials when the primary (shape) cue set was physically defined by the contours of the secondary cue set (color).

Method

Stimuli: The stimulus shapes were drawn from a group of shapes used by Pfafflin (1960). The eight stimuli used for the highly discriminable shape conditions (HD) of the study were all from her "low pre-stimulus differentiation" list while the eight shapes for the less discriminable shape condition (LD were all variations of a single shape selected from her "medium pre-stimulus differentiation" list. (See Fig. 9.) For the variations in the LD stimulus set the outside geometric dimension was held constant while the positions of the two internal rectangles were independently shifted a small distance either horizontally or vertically (Attneave and Arnoult, 1956) resulting in a set of stimuli that could be discriminated only with difficulty. The stimulus shapes for the conditions (HDLD) in which one half of the shapes were highly discriminable and the remainder less discriminable were a combination of four shapes from the LD set and four from the HD set. A pretest, consisting of 2" outline shapes drawn on index cards, was used for determining the shapes for this condition. The four shapes drawn from the HD condition were those learned most easily by shape alone, while those drawn from the LD condition were those most difficult to learn by shape alone. Thus, the pretest made possible the identification of subsets of four shapes that were the hardest (H) and the four shapes that were easiest (E) with each assignment to subset determined by the relative number of errors that occurred for each item on the pretest.

The colors used for the original plates in the relevant color condition (R) were created by using Craftint Inc. "Color Match" and "Color Vu" paper, a paper with a high degree of control for color range and consistency. (Appendix O.) The response numbers (2 through 9 inclusive) were lettered with a Leroy lettering guide in India ink and were centered directly below the shapes such that they were approximately one-sixth of the size of the shapes when displayed. The colors were chosen because they appeared to be readily discriminable from one another. However, when they were photographed on 35mm Ektachrome film this difference, especially between the red and the orange, became somewhat less apparent, although still readily discriminable. The stimuli for the irrelevant color condition were all created in a manner similar to the above shapes but all of the shapes utilized the red "Color Match" paper. (See Fig. 9.)

The 16 transfer test slides (eight color slides and eight shape slides) were also photographed on 35mm Ektachrome film. The test shapes were identical in form and construction to those used in the training trials but utilized a black construction paper instead of the colors. The test colors were constructed by filling the entire projection area of each slide with one of the eight colors used in the training shapes.

Procedure: One of the two experimenters (one male, one female) asked S to sit at a table facing a rear projection screen. Then E turned off the lights, leaving the room only dimly lit from the ambient window light, and read a set of instructions to him. (See Appendix L.) The Ss were each asked to anticipate the response for each stimuli and respond even if he were uncertain of his answers. The stimulus figure was presented for a two second anticipation interval and was immediately followed by a shutter, positioned on the back of the screen, dropping to reveal the response term for two seconds. An unfilled two second delay then followed the response term and preceded the next stimulus term.

Training was continued until S completed two consecutive errorless trials (100%). Then all Ss were given a transfer test consisting of the eight shapes presented in solid black, and the eight colors presented in a manner such that each of the colors used with stimuli in training of color conditions filled the entire screen. The eight shapes, randomly ordered, were presented first and were immediately followed by the eight colors, also randomly ordered. In addition to this final transfer test, half of the Ss were also previously tested with the same transfer test upon completing two consecutive trials with a total of 11 or more correct responses (69 %).

Apparatus: This experiment took place in a room that was about 10' by 10'. E sat at a table which supported a 12" by 12" rear projection screen at the opposite edge, approximately 30"

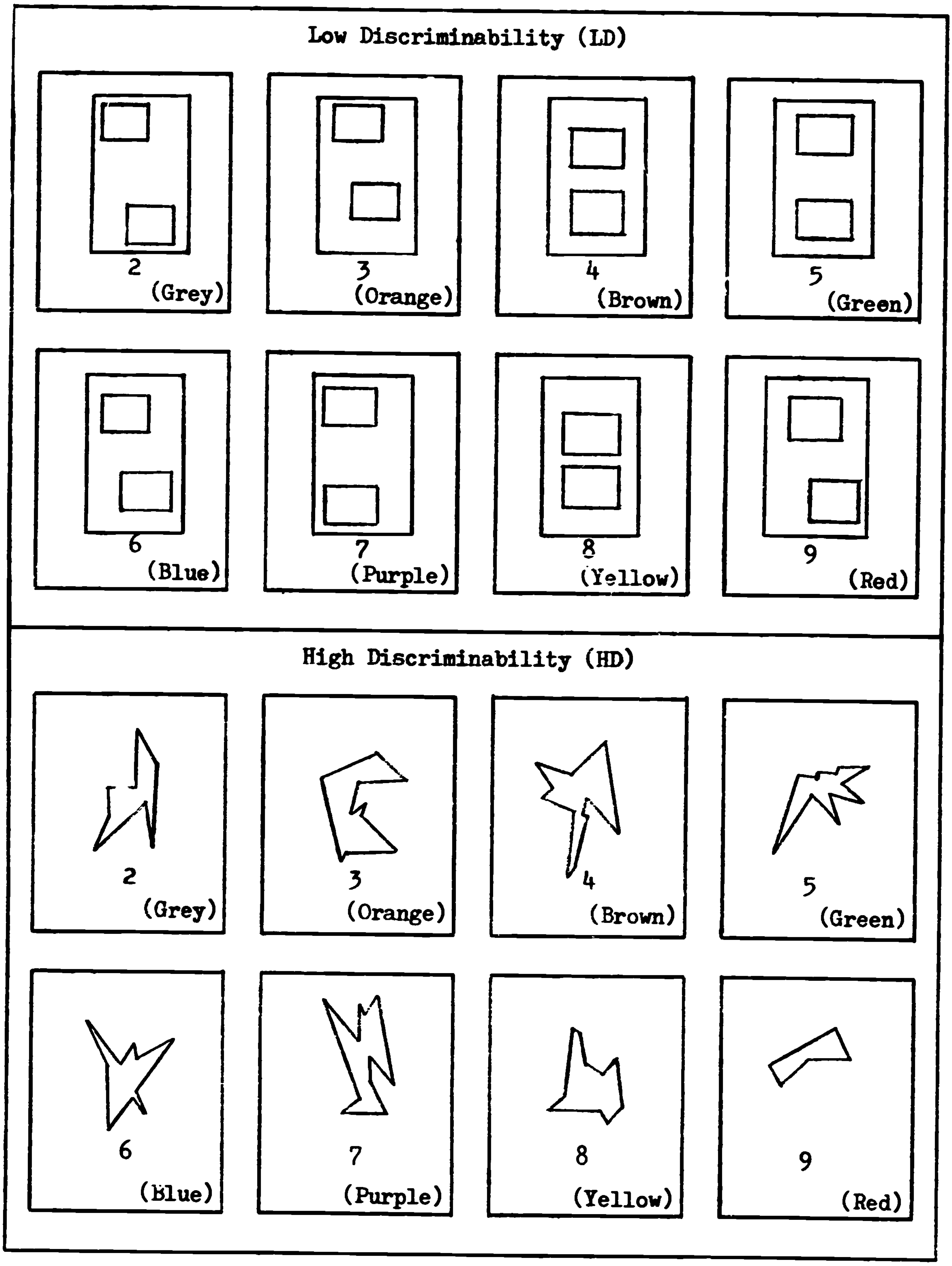

Figure 9. Stimulus Figures. Response terms were numerals in lower portion of frame. Color of figure used in Relevant (R) conditions is indicated in parentheses. (Color name not present in actual stimulus materials.) Mixed discriminability (HDLD) list consisted of HD stimuli 2, 8, 7, 3 and LD stimuli 6, 9, 4 and 5.

from the $\underline{S}$. Two Carousel slide projectors were mounted on a stand behind the screen such that one projector was positioned slightly above and behind the other and such that both were angled in order to project nearly congruent images on the screen. A shutter, immediately behind the rear-projection screen, was activated during the training trials by a solenoid so that the shutter interupted the lower two inches of the stimulus display which included the numerical response term. The solenoid action of closing the shutter produced a very audible noise.

Two projectors were utilized in order to present the transfer test slides without delay following the attainment of criteria by $\underline{S}$. Without two projectors a delay would have resulted between anticipation learning trials and the transfer test trials. The projector slide trays, each held eighty slides, and therefore, permitted the presentation of ten consecutive randomly selected permutations of the slide set after which $\underline{S}$ was shown the repeated slide sequence until criterion was attained. (See Appendix K.) Fig.10 shows the apparatus used in this study.

Subjects: The 108 $\underline{S}$s were Indiana University undergraduate educational psychology and graduate audio-visual students participating as a part of course requirements. $\underline{S}$s were assigned randomly to the training conditions as they arrived for the experiment and no $\underline{S}$ was disqualified. The materials were pretested on a convenient sample of eight Indiana University male graduate students.

Experimental design: In order to determine the effect of learning paired associate responses as a function of shape difficulty, criterion level, and presence or absence of color this study utilized three shape conditions (HD, LD, and HDLD), two criterion level conditions (100% and 69%) and two color conditions (R and I). In addition to these conditions the two within subject variables which were manipulated were test content (S and C) and relative shape difficulty (E and H). Thus, the experimental design was a five factor experiment with repeated measure (Winer, 1962) as shown in Table 4.

Results

The dependent variables were number of trials required to reach a criterion of two errorless trials (100%) and number of errors on color only (C) and shape only(S) retention tests given immediately following criterion trials. Summary of the raw data is presented in Appendix N. Table 5 shows the mean number of trials required to reach 100% criterion by Ss in each training condition. Analysis of variance (Appendix T) showed both color relevant (CR) and shape discriminability (D) to be significant factors, $F(2,96)=14.70$, $p<.001$ and $F(2,96)=20.11$, $p<.001$, respectively. Inspection of Fig.11 shows that performance of

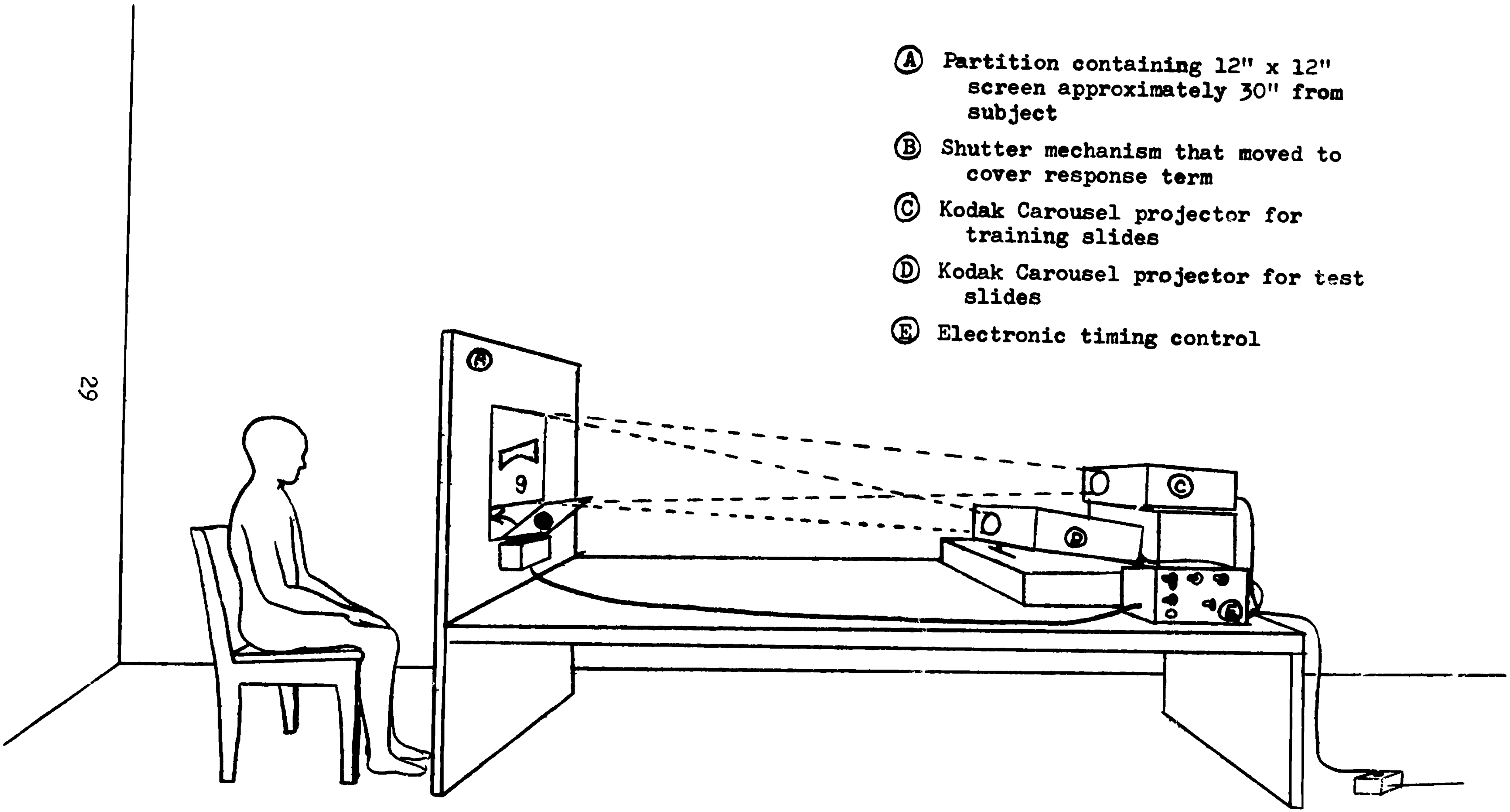

Fig. 10. The Appratus Consisted of a Rear Projection Screen, with a Moving Shutter and Two Carousel Slide Projectors

TABLE 4. GENERAL EXPERIMENTAL DESIGN FOR TRANSFER DATA INDICATING NUMBER OF OBSERVATIONS PER REPLICATIONS (N)*

Shape discriminability (D)	Shape difficulty (E-H)	Color relevance (CR)							
		Relevant (R)				Irrelevant (I)			
		Criterion level (L)				Criterion level (L)			
		100% only		100% and 69%		100% only		100% and 69%	
		Test (T)		Test (T)		Test (T)		Test (T)	
		Shape (S)	Color (C)	Shape (S)	Color (C)	Shape (S)	Color (C)	Shape (S)	Color (C)
Low (LD)	Easy (E)	4	4	4	4	4	4	4	4
	Hard (H)	4	4	4	4	4	4	4	4
Mixed (HDLD)	Easy (E)	4	4	4	4	4	4	4	4
	Hard (H)	4	4	4	4	4	4	4	4
High (HD)	Easy (E)	4	4	4	4	4	4	4	4
	Hard (H)	4	4	4	4	4	4	4	4

*N = 9

relevant (R) and irrelevant (I) color groups were much more widely separated with low discriminability stimuli (LD) than with more discriminable (HD) stimuli, $F(2,96)=7.38$, $p<.01$. Appendix P reveals that there was no difference between conditions receiving (69% and 100%) and those that did not receive (100% only) a transfer test at the 69% criterion level (L) prior to reaching the 100% criterion level.

The transfer test data were then summarized. The mean number of errors for all conditions on the shape only (S) test given following the attainment of 100% criterion level (L) was summarized in Table 6. (The analysis of variance appears in Appendix U.) The difference in levels of color relevance (CR), shape discriminability (D), criterion level (L), and shape difficulty (E-H) were all associated with significant differences in an analysis of variance, $F(1,96)=114.37$, $p<.001$; $F(2,96=42.10$, $p<.001$; $F(1,96)=11.17$, $p<.01$; $F(1,96)=29.66$, $p<.001$, respectively

TABLE 5. MEAN NUMBER OF TRAINING TRIALS TO REACH 100% CRITERION AS A FUNCTION OF SHAPE DISCRIMINABILITY (D), COLOR RELEVANCE (C), AND CRITERION LEVEL (L)

Shape discriminability (D)	Color relevance (CR): Relevant (R), Criterion level (L): 100% only	69% and 100%	Irrelevant (I), Criterion level (L): 100% only	69% and 100%	D
Low (LD)	15.56	14.33	24.35	28.44	20.66
Mixed (HDLD)	11.44	10.00	17.22	13.22	12.95
High (HD)	13.33	9.56	11.00	12.67	11.62
100% only	13.45		17.55		15.48
69% and 100%		11.30		18.22	14.68
C	12.36		17.82		15.08

(Appendix P). In the CR condition the group trained with color relevant (R) cues made more errors than the group trained without color relevant (I) cues. The difference between R and I color

TABLE 6. MEAN NUMBER OF ERRORS ON SHAPE (S) TRANSFER TEST AT 100% CRITERION LEVEL AS A FUNCTION OF SHAPE DISCRIMINABILITY (D), COLOR RELEVANCE (CR), AND CRITERION LEVEL (L)

Shape discriminability (D)	Shape difficulty (E-H)	Color relevance (CR)				E-H	D
		Relevant (R)		Irrelevant (I)			
		Criterion level (L)		Criterion level (L)			
		100% only	69% and 100%	100% only	69% and 100%		
Low (LD)	Easy (E)	2.33	1.67	.33	.44	1.19	1.54
	Hard (H)	3.22	2.78	1.00	.55	1.88	
Mixed (HDLD)	Easy (E)	.55	.33	.00	.11	.25	.80
	Hard (H)	2.78	1.89	.67	.00	1.34	
High (HD)	Easy (E)	.89	.44	.22	.00	.39	.35
	Hard (H)	.67	.11	.11	.00	.22	
100% only		1.77		.39		1.08	
69% and 100%			1.20		.37	.79	.93
CR		1.49		.38			

groups was less marked for more discriminable (HD) shapes, $F_{CRxD}(2,96)=14.70$, $p<.001$, (Appendix X) and for the easier pairs, $F_{CRxE-H}(1,96)=13.65$, $p<.001$. The interfering effect of prior color relevant training was most noticeable when the least discriminable (LD) stimuli had been associated with color relevant (CR) cues. As indicated in Fig. 12 the large increase in errors made for color relevant (R) groups in both low discriminable (LD) and easy-hard (E-H) groups resulted in a significant D x CR x E-H interaction, $F(2,96)=7.73$, $p<.001$.

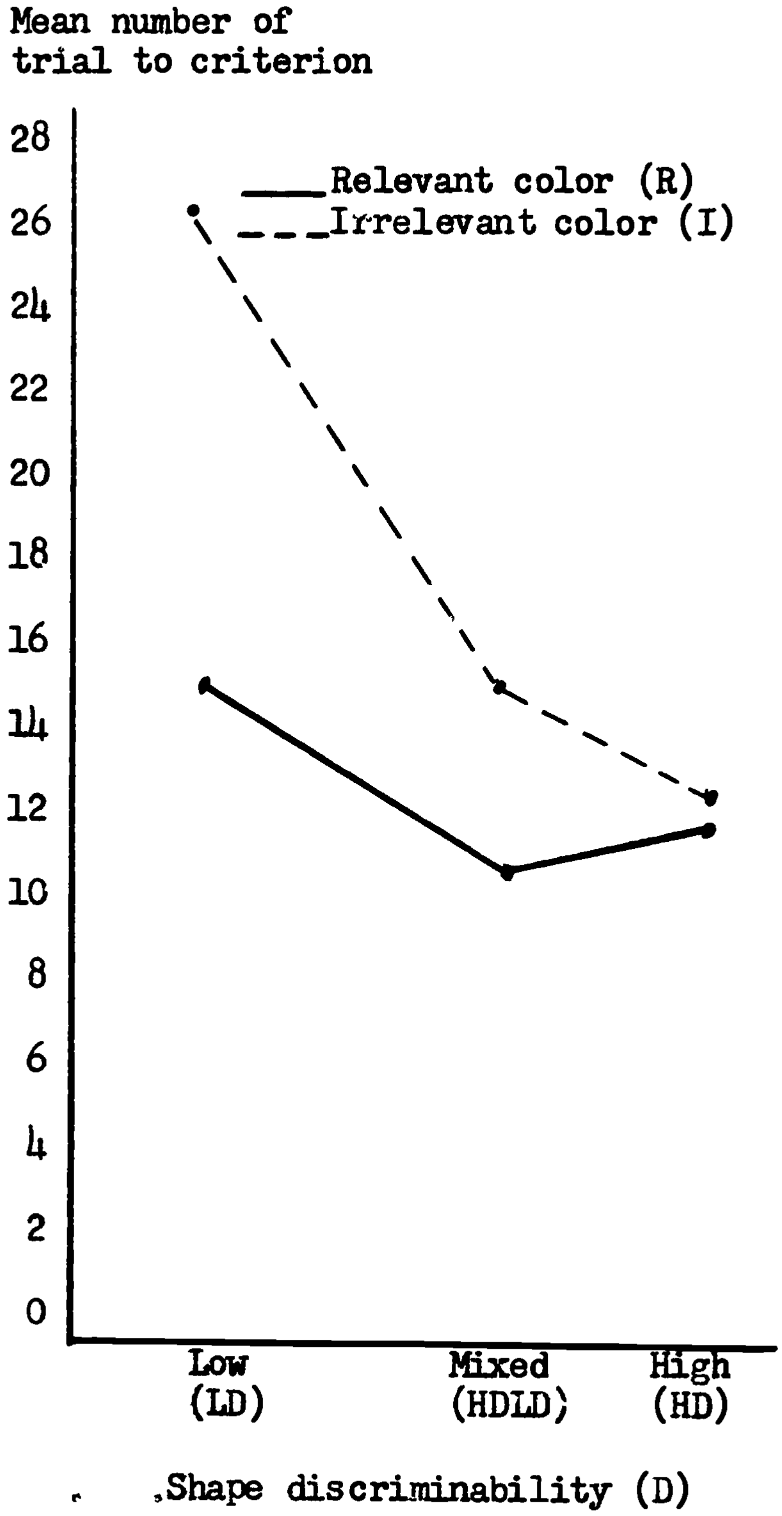

Fig. 11. Mean Number of Trials to Reach 100% Criterion Level for Three Levels of Shape Discriminability (D) and Two Levels of Color Relevance (CR)

Evidence relating to possible cue selection was obtained by comparing the effects of training upon color shape tested separately. Color (CR) and shape (S) transfer test means for Ss trained in color relevant (R) conditions were tabulated in Table 7. (See Appendix V for analysis of variance.) Conditions associated with more discriminable shapes (HD) and the occurrence of a prior test (69%) had significantly fewer errors, $F(1,48)=8.24$, $p<.001$ and $F(1,48)=21.83$, $p<.001$, respectively. Overall, fewer errors were made on the shape (S) test than on the color (C) test, $F(1,48)=25.04$, $p<.001$. Relative performance on color (C) and shape (S) tests varied markedly as a function of the discriminability of the shapes used in training. When shapes were low in discriminability (LD) performance was best on shape (S) test but when shapes were highly discriminable (HD) performance was

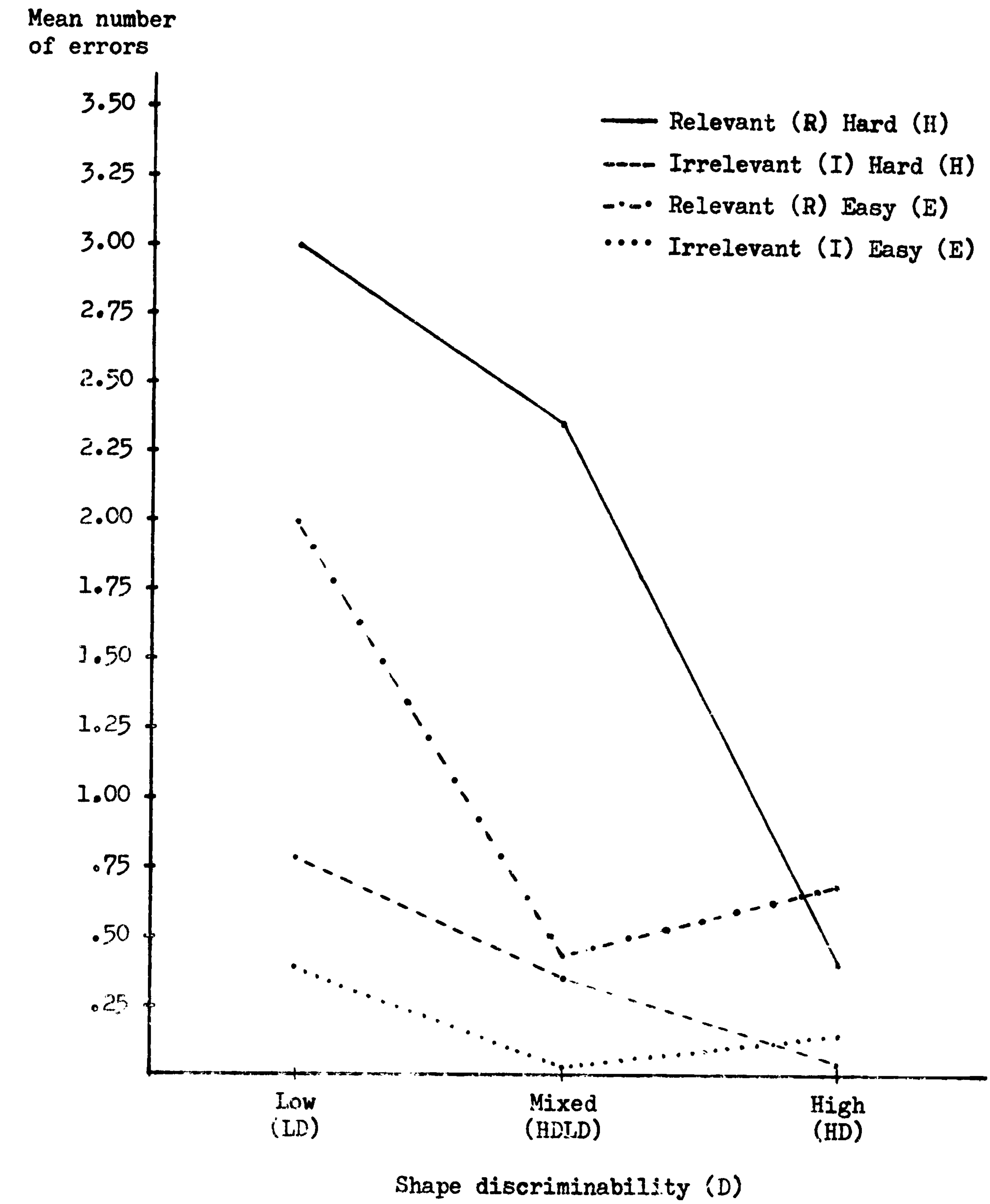

Fig. 12. Mean Number of Errors on 100% Shape Only Transfer Test for Three Levels of Shape Discriminability (D), Two Levels of Color Relevance (CR), and Two Levels of Shape Difficulty (E-H)

TABLE 7. MEAN NUMBER OF ERRORS ON FINAL TRANSFER TEST FOR GROUPS WITH (69% AND 100%) AND WITHOUT (100%) A PRIOR TRANSFER TEST AS A FUNCTION OF SHAPE DISCRIMINABILITY (D), SHAPE DIFFICULTY (E-H), AND CRITERION LEVEL (L)

Shape discriminability (D)	Shape difficulty (E-H)	Color relevance (CR): Relevant (R); Criterion level (L): 100% only; Test: Shape	Relevant (R); 100% only; Test: Color	Irrelevant (I); 100% of 69% and 100%; Test: Shape	Irrelevant (I); 100% of 69% and 100%; Test: Color	E-H	D
Low (LD)	Easy (E)	2.33	1.11	1.67	1.22	1.58	1.91
	Hard (H)	3.22	1.89	2.78	1.11	2.25	
Mixed (HDLD)	Easy (E)	.55	1.89	.33	2.22	1.29	1.70
	Hard (H)	2.78	2.22	1.89	1.55	2.11	
High (HD)	Easy (E)	.89	2.44	.44	1.89	1.42	1.35
	Hard (H)	.67	2.55	.11	1.78	1.28	
100% only		1.76		1.20		1.48	1.65
69% and 100%			2.02		1.62	1.82	

relatively better on the color (C) test. This resulted in a significant D x S-C interaction, $F(2,48)=10.96$, $p<.001$ and is represented in Fig. 13. Subjects receiving only one transfer test (100%) made slightly more errors on the 100% transfer test than Ss that had received a prior transfer test (69% and 100%). This difference, which can be seen in Appendix S, was significant, $F(2,48)=21.83$, $p<.01$.

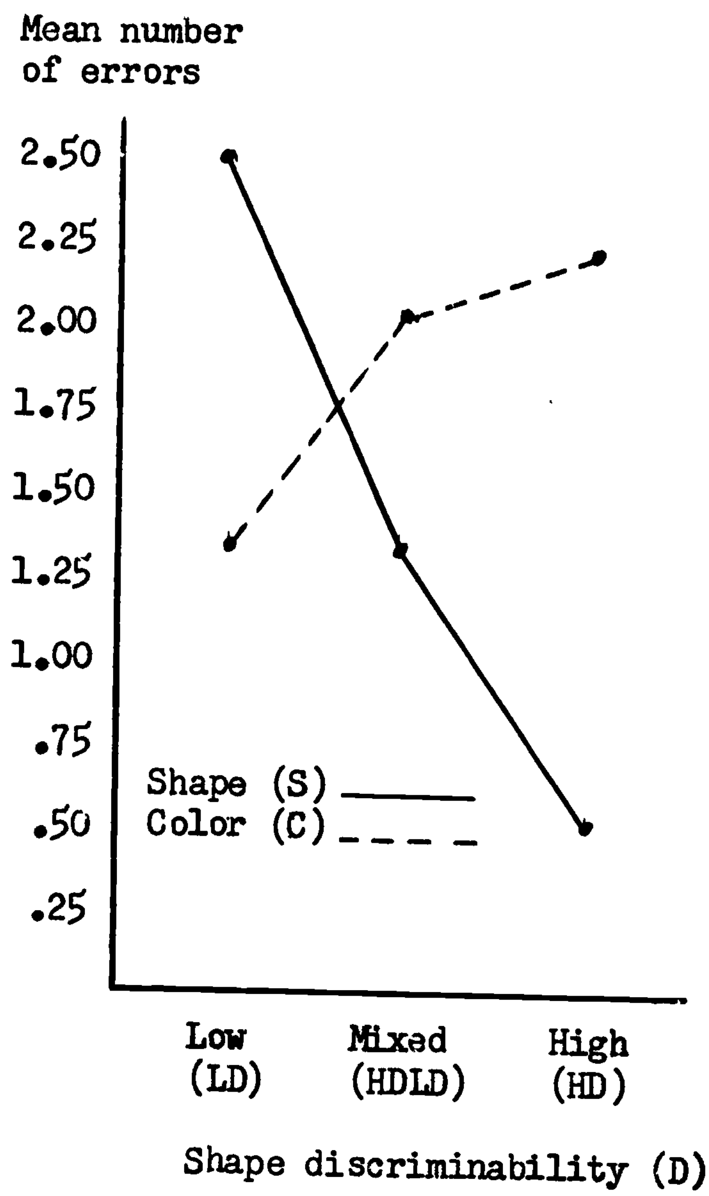

Fig. 13. Mean Number of Errors on 100% Shape (S) and Color (C) Transfer Test for Three Levels of Shape Discriminability (D), and Two Levels of Test (T)

In order to investigate the possibility of an interaction between color-shape (C-S) and the occurrence of early testing (L), two additional analyses of variance were performed. One considered the mean number of errors on the first transfer test presented (69% level for groups receiving two transfer tests and 100% level for groups receiving only one transfer test) over all color relevant conditions on both shape (S) and color (C) stimuli. The other, performed only on data from color relevant (R) groups, compared performance on early (69%) and late (100%) transfer tests for the same subjects. It is obvious from these analyses, Appendices W and X, respectively, that there was no interaction of the criterion level (L) with any of the other major variables.

The total number of correct responses on the transfer tests do not indicate the extreme to which correct responses related to specific items presented during training. Each cue in the color-shape stimuli presented during training was individually tested on color only (C) and shape only (S). Thus, a correct response could be made on the shape test only ($\overline{C}S$), on the color test only ($C\overline{S}$), on both tests (CS), or on neither test ($\overline{CS}$). A marked difference

TABLE 6. MEAN NUMBER OF RESPONSES CORRECT ON THE CO R TEST ONLY ($C\bar{S}$), SHAPE TEST ONLY ($\bar{C}S$), BOTH COLOR AND SHAPE TEST (CS), OR ON NEITHER TEST ($\overline{CS}$) FOR Ss TRAINED UNDER COLOR RELEVANT CONDITIONS

Training conditions	Responses correct on transfer test following attainment of indicated criterion level							
	69%				100%			
	$C\bar{S}$	$\bar{C}S$	CS	$\overline{CS}$	$C\bar{S}$	$\bar{C}S$	CS	$\overline{CS}$
LOW SHAPE DISCRIMINABILITY (LD)								
Tested at 100% only					3.56	.56	1.89	2.00
Tested at 69% and 100%	3.44	.56	1.22	2.78	3.22	1.22	2.44	1.11
MIXED SHAPE DISCRIMINABILITY (HDLD)								
Tested at 100% only					1.89	2.67	2.00	1.44
Tested at 69% and 100%	1.11	2.78	2.22	1.89	1.44	2.22	3.67	.67
HIGH SHAPE DISCRIMINABILITY (HD)								
Tested at 100% only					.67	4.22	2.22	.89
Tested at 69% and 100%	.89	4.00	1.67	1.44	.11	3.33	4.11	.44

between $C\bar{S}$ and $\bar{C}S$ categories of the various experimental conditions was reflected in the analysis of the transfer test data reported above. However, the number of items correct on both the test (CS) was not directly apparent. Therefore, performance for each S was tallied for each item under one of the four headings, $\bar{C}S$, $C\bar{S}$, CS and $\bar{C}\bar{S}$, (Appendix Y) and the mean number of correct responses under each heading was reported in Table 8. This table indicates that there were a substantial proportion of such CS items for each group.

The performance of Ss in each of two testing conditions were judged to fall in one of two categories. In this manner the relative frequency with which Ss conditioned responses to both sets of relevant stimuli (C-S) as a function of the occurrence of a prior transfer test was categorized. These categories were: (1) over half of the correct items conditioned to both C and S and, (2) half or less of the correct items conditioned to both C and S. Ss with a ratio (CS/CS+$C\bar{S}$+$\bar{C}S$) of over .50 were assigned to one category and those equal to or less than .50 were assigned to the other as summarized in Table 9. The difference in occurrence or non-occurrence of a

TABLE 9. SUBJECTS WITH HIGH AND LOW RATIO OF ITEMS WHICH WERE CORRECT ON BOTH C AND S TRANSFER TEST FOR GROUPS WITH AND WITHOUT PRIOR TRANSFER TEST TRIAL

Occasion of transfer test trial prior to reaching 100% criterion	Subjects with indicated ratio of CS/$C\bar{S}$+$\bar{C}S$+CS	
	>.50	≤.50
69%	11	16
None	3	24

prior test trial is associated with a significant difference in ratio of responses conditioned to both C and S, Fisher's exact probability = .02 (Siegel, 1956, pp. 96-104).

The difference is in the direction of a greater frequency of Ss with a higher ratio of CS items being assigned to the group that had prior criterion testing. When the data are similarly arranged for the three subsets of Ss with differing degrees of discriminability of stimuli similar evidence of increased CS frequency associated with prior criterion testing was obtained for HD and HDLD groups, Fisher's exact probability +.003, but there was no difference in the LD group.

Discussion

The results of this experiment are consistent with earlier findings (Underwood, Ham, and Ekstrand, 1962; Jenkins and Bailey, 1964; Weiss and Margolius, 1954) interpreted as evidence of a cue selection process in the context of paired associate learning with supplementary color cues that were relevant during training. In the present experiment the addition of relevant color cues to the shape cues was associated with a significant reduction in the number of trials required to reach the training criteria but was associated with a relatively greater number of errors on the shape transfer test. Since the present study utilized shape cues consisting of contours defined by the edges of colored shapes, it seems that cue selection could not be readily attributed to a physical orienting response. This is evident because orientation responses required to sample shape cues would also have been appropriate to sampling color cues. The presentation of highly discriminable shapes with relevant color cues was consistently associated with relatively high performance on the shape only test and relatively low performance on the color only test. Therefore, it appears that even though attention to shape cues required that S maintain orienting responses appropriate for sensory reception of color the latter were not conditioned with a high probability under these training conditions. Postman (1964) and Mechanic (1962) argue that in the case on intrinsically associated stimuli, such as shape and color as used in this study and that of Bahrick (1954), that the orienting task does not insure a class of postulated discriminating responses to both sets of stimuli although sensory reception of both is insured. If the postulated discriminating response is a functi[illegible] [illegible]f stimulus discriminability and testing procedure as well as imposed orienting task then the present data may be accounted for in terms of self imposed orienting tasks.

A cue selection model which assumes that all elements are sampled with equal probability (Atkinson and Estes, 1963) seems to require additional assumptions to account for the findings of this study. Likewise, a multiple process model that includes a discrimination or orientation step (Atkinson and Estes, 1963, p. 257) seems to run into difficulty. If cues are thought to correlate highly with the simple physical characteristics of the stimulus, then sampling of shape cues would seemingly require sampling of equally valid color cues also. The cue selection aspects of this study's data seem to be more consistent with a single element model for concept identification (Restle, 1962) in which a single strategy is selected and retained if reinforced. However, in order for this to be an acceptable explanation it must be argued that valid strategies are unequally distributed across color and shape cues in this experiment and that those with the highest frequency are most likely to be sampled. Then strategies may presumably be attached to various abstractions of the stimulus set including color only, shape only, or even a combination of them both.

Much of the data variance could not be accounted for solely in terms of cue selection. Further analysis of the data revealed that in a significant number of cases both color and shape were the occasions for correct responses when both the shape and color were paired in training trials. The present data do not offer a basis for resolving the apparent conflict between the part of the data suggesting cue selection and the part that is consistent with simultaneous sampling of multiple cues. One finding that might help explain this apparent conflict was reported in a study by Estes and Hopkins (1961). They reported that when one of the training patterns appears as a component of the test compound *Ss* may subsequently respond either to the training pattern or to *its* sub-patterns as units. They also found evidence that the pattern response apparently becomes increasingly dominant over constituent responses as the training progresses. An analysis of the present data comparing the performance of groups tested twice with groups tested once suggested another possible explanation. There was a shift from items correct on only one of the tests (shape or color) to items that were correct on both shape and color for subjects receiving tests at the 69% and 100% level. However, upon comparing the earlier transfer test performance of the first test (69%) for subjects receiving two tests with the later (100%) transfer test performance of subjects receiving only one test there was no evidence for such a shift. Thus, it is possible that the early transfer test (69%), which included a color only test, allerted *S* to condition responses to both sets of cues.

These data, then, seem to support the assumption that the interpolated test trials had the effect of increasing the probability of sampling from the cue set that had not been previously sampled. Thus, while *S* may sample from only one set of available cues, a redefinition of the valid cues by an interpolated test may result in a change in cue sampling strategy. Thus, *S* may have had a sampling bias which led him to sample from both cue sets during the training task. It is not possible to determine from these data whether conditioning of multiple cues proceeds simultaneously or serially but it should be noted that an interpolated test was associated with some serial conditioning. This effect, however, may have been a function of a complex, mediating process of self-instruction (Goss, 1961) employed at the time of the early transfer test.

Summary

This paired associate learning task required 108 college students to observe a series of slides presented on a rear projection screen. Each set of stimuli was at one of three levels of shape discriminability and one of two levels of color relevance and was conditioned to one of two criterion levels. *S*

was required to verbally anticipate with a single numerical digit response to each of eight stimuli and was then shown the correct response.

The results of this study indicate a cue selection process in the context of paired associates employing colored shape cues. Since the color and shape cues were highly integrated it also revealed that this cue selection cannot be readily attributed solely to physical orientation responses. The study also indicated a shift from single to multiple cue selection as a function of the interpolated tests but not as a function of the learning criterion level.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The series of studies reported in this project generally confirm earlier findings of effects of manipulating the relevance of color upon learning responses to associated stimulus components. The effects obtained were generally in the direction of a positive relationship between relevance of the supplementary color and the number of errors emitted during the acquisition trials. The magnitude of this relationship was shown to be a function of the extent to which instructions or practice procedures required making discriminating responses to the supplementary color component. Instructions or procedures that made only the most casual or even negative reference to color were in some instances effective in increasing the magnitude of effect of the color component.

The first three experiments involved children averaging ten years of age. The last two involved college students as subjects. In general the results across age groups is consistent with the findings in other experiments that suggest that cue selection may be more highly developed in adults and while children are able to modify response tendencies as a function of instructions and practice procedures, they are relatively less able to functionally restrict the stimulus universe. It appeared that under a given combination of instructions and test conditions that relevant color cues might be effectively ignored by adults. Although a completely comparable experiment was not conducted with children there was strong evidence that under rather similar conditions children could reduce but not functionally eliminate the effect of color.

A tentative conclusion is that facility in cue selection is a function of age and that by age ten children have some facility but it is not as well developed as that of adults. This cue selection facility may result in positive or negative transfer to tasks involving compound stimuli that do not include the color components, depending primarily upon whether the selection of the color component is followed by the selection of the shape component. If either component is conditioned exclusively or shape is conditioned before color there seems to be no basis for expecting facilitation. On the other hand if both are conditioned independently, as seemed to be the case in Experiment I, facilitation would be expected if the color cues were conditioned well before the shape cues providing a basis for a prompted response to shape, or if color cues were relatively highly discriminable and provided a basis for more readily discriminating the shape cues. This discrimination function may occur independently of or concurrently with a prompting function.

If it is the case that children tend to condition shape and color cues independently then procedures should be considered for increasing the probability of a prompting effect. Also careful attention must be given to the possibility of irrelevant color occuring in the transfer task stimuli since these would be interfering for those trained with relevant color but not for those trained without supplementary relevant color.

The sizeable effects of instructions and procedures upon the effects of supplementary cues reemphasises the importance of these variables. The procedure in Experiment II of having Ss attempt to state their mneumonic devices provided the basis in Experiment III for introducing the most powerful variable of the entire series of experiments. It may be that use of protocol analysis combined with experimental test of derived hypotheses may provide a basis for greatly increasing the effectiveness of procedures such as those used in this series. Caution is, of course required. An example in this study of the failure of the subject protocol to reflect the range of relevant processes is the fact that in Experiment II Ss consistently failed to mention color even though the data showed it to be associated with a significant effect.

Before suggestions for practical application of the findings of this series could be made with any degree of confidence further work seems indicated regarding the developmental factor, the role of the supplementary color component with respect to mediation, discrimination and prompting. It does seem clear that the evidence is clear that indiscriminate use of supplementary color without consideration of age, instructional and practice conditions and the transfer task conditions can either be expected to contribute nothing or to have an interfering effect, while careful consideration of these conditions may be expected to substantially improve performance in training and transfer tasks.

A most promising procedure that was shown to be effective with children and adults was that of indicating that an irrelevant color dimension should be ignored. Both age groups showed evidence of being able to effectively ignore the irrelevant color component. However, again it must be noted that the results suggest at least one restriction in that the nature of the test situation with regard to color relevance may modify the effects of the verbal instructions.

The procedure of indicating that color may help or introducing criterion tasks that demonstrate its relevance were also shown to be highly effective in enhancing the effectiveness of relevant color. Directing attention to the color dimension may be more effective in some ways than others, however. For example requiring S to name the color on each trial had a generally interfering effect.

SUMMARY

Color coded shapes were stimulus terms in a series of five paired-associate experiments. The degree of relevance of the color coding was an independent variable in each of the studies. Children averaging ten years of age were Ss in the first three experiments and college students were Ss in the last two. In one or more of the experiments practice conditions were varied by imposing differing requirements of color or shape naming during practice, varying the length of anticipation interval, varying the color relevance and temporal location of the test trial and varying the instructions regarding the potential relevance of color. The stimuli were varied with respect to inter- and intra-list differences in discriminability and meaningfulness of shapes. Relevant color was found to facilitate acquisition to the compound stimulus in general and irrelevant, noisy color was interfering. However when tested on the shape stimulus alone evidence of selection of the more readily discriminated color component was obtained. The degree of color selection was affected by the discriminability of the shape component, color relevance on test trials, instructions regarding color relevance and age of S. Selection of color cues was only partial and shape cues were also conditioned. Under appropriate conditions relevant color coding during training facilitated performance on transfer with only the shape components.

The results were discussed in terms of S-R and hypothesis testing learning models and in terms of cognitive development of children. The results support the assumption that color coding effects may be interfering or facilitating depending upon factors other than the visual display characteristics and further that procedures assuring facilitation with children may be inappropriate with adults.

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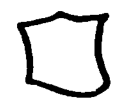
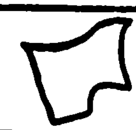
Appendix A

Instruc ions for Experiment I

I'm going to show you some pictures of several countries. These pictures will be shown to you one at a time on the screen that you see in front of you. First, we will go through and look at all the countries and their names. Next, I will start showing you the pictures again, but this time you will start trying to name them. Each picture will only appear on the screen for a few seconds, so try to tell me the name of the country, out loud, as soon as possible before the picture disappears. Do not use a sentence to tell me the name of the country, but just the one word. After each picture, and your answer, there will appear on the screen the name of the country. In this way you can tell if your answer was correct, and this also helps you learn the names of the countries. You will see the pictures of the countries over and over again until you learn the correct name for each one. You may guess the name of the country if you are not sure what the name is. Your job, then, is to learn the names of the countries. In order to let you know how you are doing, be sure to tell me each country's name, if you can, during the time you see it on the screen and not after it has disappeared. After each picture I'll then give you the correct name of the country. We'll do this over and over until you have learned the names of all the countries. Questions? [E will answer any questions from the above instructions.]

Appendix B

Response Terms and Associated Shape and Color Components of Compound Stimuli for Each Training and Transfer Condition in Experiment I

Display function of stimulus element	Experimental conditions required for displaying stimulus element	Experimental trial required for display of stimulus element	Stimuli					
Response terms	All conditions	All trials	Egypt	Bulgaria	Poland	Romania	Equador	Surinam
Shape component	All conditions	All trials						
Color Component	Relevant Redundant (RR)	All trials	Red	Green	Yellow	Blue	Brown	Violet
	Irrelevant Redundant (IR)	All trials	Red	Red	Red	Red	Red	Red
	Independent Irrelevant (II)	Trial N	Red	Violet	Yellow	Blue	Green	Brown
		Trial N+1	Brown	Blue	Violet	Green	Blue	Yellow
		Trial N+2	Yellow	Green	Blue	Violet	Violet	Violet
		Trial N+3	Violet	Yellow	Green	Yellow	Yellow	Blue
		Trial N+4	Blue	Brown	Brown	Brown	Brown	Green
		Trial N+5	Green	Red	Red	Red	Red	Red

Appendix C

Data and Analysis for Experiment I

PART I Total errors to reach criteria on training and transfer tasks Experiment I

Subject Number	Training Condition	Training Errors	Transfer Condition	Transfer Errors	Total Errors
1	IR	49	RR	2	51
2	IR	26	RR	0	26
3	IR	10	RR	2	12
4	IR	68	RR	0	68
				4	
5	IR	60	II	6	66
6	IR	10	II	0	10
7	IR	16	II	0	16
8	IR	14	II	1	15
		253		7	
9	RR	10	IR	1	11
10	RR	26	IR	5	31
11	RR	32	IR	4	36
12	RR	15	IR	2	17
				12	
13	RR	14	II	13	27
14	RR	23	II	8	31
15	RR	20	II	3	23
16	RR	22	II	13	35
		162		37	
17	II	45	IR	0	45
18	II	61	IR	4	65
19	II	22	IR	0	22
20	II	128	IR	0	128
				4	
21	II	37	RR	1	38
22	II	30	RR	2	32
23	II	45	RR	1	46
24	II	73	RR	6	79
		441		10	
Total		856		74	930

PART II Mean Errors to Criterion on Training, Transfer and Combined Training and Transfer Trials, Experiment I for the conditions of color relevance.

Training Condition	Errors	Transfer Condition	Combined Training & Transfer
RR	20.25	IR 3.00 II 9.25	26.38
IR	31.62	RR 1.00 II 1.75	33.00
II	55.13	RR 1.00 IR 2.25	56.88

PART III Analyses of Variance of Training Errors, Experiment I

Source	df	MS	F
Relevance	2	2,530.53	4.34*
Error	21	584.87	

* $p < .05$

PART IV Analysis of Variance of Transfer Error, Experiment I

Source	df	MS	F
Training-Transfer Relevance	5	39.07	5.16**
Error	18	7.58	

** $p < .005$

PART V Analysis of Variance of Combined Errors on Training Task, Experiment I

Source	df	MS	F
Training	2	2,058.88	2.54
Error	21	807.07	

PART VI Newman-Keuls interval test comparing differences in Total errors on Transfer tests for each Training-Test combination, Experiment I

	4 IR-RR	4 IR-RR	7 IR-II	10 II-IR	12 RR-IR	37 RR-II
IR-RR	---	---	3	6	8	33 **
II-RR		---	3	6	8	33 **
IR-II			---	3	5	30 **
II-IR				---	2	27 **
RR-IR					---	25 **
RR-II						---

** $p < .01$

Appendix D

Instructions in Experiment II

1 Apparatus Set, Write Name, Condition, Slide #76, OFF, STOP, TRAIN.

(IF E IS NOT READY "I'll explain what we are going to do in just a minute.")

WHEN E IS READY "You are going to learn which maps go with each of these countries. Since the names are a little hard to pronounce we are going to try to remember just the initial or first letter in each name. (POINTING TO THE NAME CARDS...) Please say the first letter in each name. (WAIT UNTIL THE CHILD SAYS "p" FOR POLAND...etc.)

E LEAVES CHILD AND GOES TO CONSOLE "You will first see the name of a country on the screen (TURN ON LOW, FWD) like this. (DISPLAY "EGYPT")

"Then you will see the map of that country like this. (PRESS FWD AGAIN)

REPEAT CONDITION ONLY "To help you remember the letter that goes with each map you are to say the letter when the map is on the screen like this..."E"..."E"..."E"...etc. (ABOUT ONE/SECOND). Please say it loud enough so it will be received by the microphone. Try it now. (BE SURE S IS RESPONDING 1/SEC.)

STRATEGY CONDITION ONLY "To help you remember the letter that goes with each map you are to try to think of some way in which the map reminds you of the letter and say it loud enough so it will be received by this microphone. Say anything that helps you remember the letter that goes with the map even though it may seem too simple or even silly. Remember, as you think of something that might help you remember which letter goes with the map be sure to say what the idea is.

Try now to think of some way to remember that the letter E goes with this map of Egypt. Say it out loud when you think of it. (IF S CAN NOT THINK OF ANY WAY IN WHICH TO RELATE E AND EGYPT ASK "Is there anything about the map that would help you remember that the map goes with "E". DO NOT SAY TO NOTICE THE COLOR OR SHAPE, ETC. IF S CAN NOT THINK OF ANYTHING SAY:) "You should try to think of some way and you can say it the next time you see the map."

OBSERVE
COLOR CONDITION ONLY "Notice that the map of Egypt is red/brown. Each map will be colored and this may help you remember which letter goes with each map.

IGNORE
NO COLOR CONDITION ONLY "Notice that the map of Egypt is red/brown. Each map will be colored but you should try to learn to tell them apart without depending upon the color of the maps.

(PRESS FWD OFF) TAPE RECORDER 17/8, REC. Volume to 2 (inner dial.)

SUMMARY "Let's make sure the instructions were clear. Please tell me now what you are to do. (CORRECT OR ADD ANYTHING NECESSARY. BE SURE THAT PRACTICE AND COLOR INSTRUCTIONS ARE CLEAR.) PRESS HIGH, RUN.

TRAINING ONLY "Remember, say anything that helps you remember the letter that goes with each map.

START PRESENTATION: BE SURE PRACTICE IS OBSERVED. DO NOT PROCEED IF S IS NOT PRACTICING.

ON TEST "Now tell me the letter for each map. At first you may not know which letter goes with which map, but you will soon learn. Try to guess even if you are not sure at first which letter goes with each map.

REPEAT CONDITION ONLY "Now repeat out loud the letter several times when the map is on.

STRATEGY CONDITION ONLY "Now try to think of some way that the map reminds you of a letter and say it out loud.

Appendix E

Number of Errors for Each Subject on Training and Transfer Tasks for Experiment II

S No.	Instruction & Practice Condition	Color Condition in Training	Training Errors	Color Condition in Transfer	Transfer Errors	Total Errors
1	0 R	II	25	RR	0	25
2	0 R	II	43	RR	0	43
3	0 R	II	31	IR	0	31
4	0 R	II	17	IR	0	17
5	0 R	II	57	II	0	57
6	0 R	II	61	II	0	61
			234		0	
7	0 R	IR	24	RR	0	24
8	0 R	IR	19	RR	1	20
9	0 R	IR	50	IR	2	52
10	0 R	IR	16	IR	0	16
11	0 R	IR	23	II	2	25
12	0 R	IR	21	II	0	21
			153		5	
13	0 R	RR	16	RR	0	16
14	0 R	RR	7	RR	0	7
15	0 R	RR	4	IR	2	6
16	0 R	RR	10	IR	10	20
17	0 R	RR	11	II	4	15
18	0 R	RR	10	II	2	12
			58		18	
			445			
19	0 S	II	12	RR	1	13
20	0 S	II	13	RR	0	13
21	0 S	II	15	IR	0	15
22	0 S	II	14	IR	0	14
23	0 S	II	61	II	0	61
24	0 S	II	45	II	2	47
			160		3	
25	0 S	IR	23	RR	0	23
26	0 S	IR	37	RR	0	37
27	0 S	IR	5	IR	0	5
28	0 S	IR	12	IR	0	12
29	0 S	IR	26	II	0	26
30	0 S	IR	7	II	0	7
			110		0	

S No.	Instruction & Practice Condition		Color Condition in Training	Training Errors	Color Condition in Transfer	Transfer Errors	Total Errors
31	0	S	RR	17	RR	0	17
32	0	S	RR	19	RR	0	19
33	0	S	RR	5	IR	0	5
34	0	S	RR	0	IR	5	5
35	0	S	RR	6	II	0	6
36	0	S	RR	5	II	1	6
				52		6	
				322			
37	I	R	II	7	RR	0	7
38	I	R	II	11	RR	0	11
39	I	R	II	4	IR	0	4
40	I	R	II	8	IR	0	8
41	I	R	II	5	II	0	5
42	I	R	II	17	II	1	18
				52		1	
43	I	R	IR	14	RR	0	14
44	I	R	IR	52	RR	0	52
45	I	R	IR	23	IR	0	23
46	I	R	IR	12	IR	0	12
47	I	R	IR	11	II	0	11
48	I	R	IR	8	II	0	8
				120		0	
49	I	R	RR	7	RR	0	7
50	I	R	RR	5	RR	0	5
51	I	R	RR	17	IR	8	25
52	I	R	RR	11	IR	5	16
53	I	R	RR	6	II	1	7
54	I	R	RR	4	II	0	4
				50		14	
				222			
55	I	S	II	11	RR	0	11
56	I	S	II	37	RR	1	38
57	I	S	II	6	IR	0	6
58	I	S	II	13	IR	0	13
59	I	S	II	37	II	0	37
60	I	S	II	3	II	0	3
				107		1	
61	I	S	IR	9	RR	7	16
62	I	S	IR	4	RR	0	4
63	I	S	IR	48	IR	0	48
64	I	S	IR	39	IR	0	39
65	I	S	IR	22	II	0	22
66	I	S	IR	7	II	7	14
				129		14	

S No.	Instruction & Practice Condition		Color Condition in Training	Training Errors	Color Condition in Transfer	Transfer Errors	Total Errors
67	I	S	RR	4	RR	1	5
68	I	S	RR	17	RR	0	17
69	I	S	RR	15	IR	0	15
70	I	S	RR	3	IR	18	21
71	I	S	RR	14	II	1	15
72	I	S	RR	2	II	11	13
				55		31	
				391			

Note: Instructional conditions, Observe (O) and Ignore (I) and practice conditions, Repeat (R) and Strategy (S) are identified for each S as are the color relevance conditions, irrelevant independent (II) irrelevant redundant (IR) and relevant redundant (RR) for both training and transfer.

Appendix F

PART I Analysis of Variance of Errors on Training Task, Experiment II

Source	SS	df	MS	F
C (Color relevance)	2,835.20	2	1417.60	8.21**
I (Instructions)	896.06	1	896.06	5.19*
P (Practice response)	40.51	1	40.51	.23
C x I	1,414.90	2	707.09	4.10*
C x P	22.75	2	11.37	.07
I x P	511.99	1	511.99	2.97
C x P x I	299.08	2	149.54	.87
error	10,356.67	60	172.61	

PART II Analysis of Variance of Errors on Transfer Task, Experiment II

Source	SS	df	MS	F
I (Instructions)	11.71	1	11.71	1.
C_1 (Training color)	94.34	2	47.17	5.29**
P (Practice response)	4.02	1	4.02	
C_2 (Transfer color)	31.75	2	15.88	1.78
I x C_1	10.08	2	5.04	
I x P	28.09	1	28.09	3.13
C_1 x P	.77	2	.39	
C_2 x I	.49	2	.25	
C_2 x C_1	174.75	4	43.69	4.90**
C_2 x P	6.02	2	3.01	
C_1 x P x I	21.37	2	10.68	1.89
C_2 x C_1 x I	41.39	4	10.69	1.90
C_2 x P x I	3.69	2	1.85	
C_2 x C_1 x P	9.85	4	2.46	
C_2 x C_1 x P x I	11.32	4	2.83	
error	321.04	36	8.92	

PAPT III Analysis of Variance of Errors on Training Task and Transfer Task Combined

Source	SS	df	MS	F
C_1 (Training color)	1900.20	2	950.10	7.47**
I (Instructions)	703.06	1	703.06	5.53*
R (Practice response)	19.02	1	19.02	
C_2 (Transfer color)	122.70	2	61.35	
C_2 x I	1000.82	2	500.41	3.94
I x P	780.19	1	780.19	6.14*
I x C_1	1629.32	2	814.66	6.41**
C_1 x R	18.35	2	9.18	
C_1 x C_2	2484.01	4	621.00	4.88**
R x C_2	44.14	2	22.07	
C_1 x I x R	158.01	2	79.01	
C_1 x I x C_2	805.42	4	201.35	1.58
C_1 x R x C_2	194.08	4	48.52	
I x P x C_2	369.24	2	184.62	1.45
C_1 x C_2 x I x P	1597.70	4	399.43	3.14*
error	4577.50	36	127.15	

Appendix G

Instructions Used in Experiment III

First, each subject was presented with a card with five colored circles on it and was asked to identify each of the five colors. The purpose of this procedure was to detect any possible color blindness in potential subjects. (No subject had to be rejected for this reason.) Then the subject was given five cards with a word (in a single instance, two words) written on each. These words comprised the practice-strategies. The five practice-strategies which had common initial letters with the appropriate responses were "ear" (Ecuador), "rubber boot" (Romania), "banner" (Bulgaria), "patch" (Poland, and "spear" (Surinam). The instructions at this point were as follows: "Would you pronounce the words on these cards and tell me what you think each one means?" The only word in this group which caused subjects difficulty was "banner." When this difficulty was encountered, the E (experimenter) helped the subject arrive at a meaning. The E would first remind the S that the word "banner" was in the title of our national anthem. If the S still could not give a meaning for the word, the E would supply the meaning, referring to a synonym, flag. The same procedure was followed with the subjects who worked with practice-strategies which did not have common initial letters with the appropriate responses. Those five practice-strategies were "mitten" (Ecuador), "overshoe" (Romania), "flag" (Bulgaria), "lake" (Poland), and "arrowhead" (Surinam). When the subjects explained what a mitten was, the E would ask what the difference was between a mitten and a glove if this distinction was not made voluntarily.

Each subject was then presented with a card which had the names of the five countries printed on it. The first letter (to become the S's response) was underlined in each name. At this time the E said, "Here are the names of five countries. I'll pronounce them for you." The E pointed to each name as it was being pronounced. After the E had pronounced the names, he said to the subject, "You will notice that the first letter of each name is underlined. Will you say the first letter of each name as I point to it?" After the S had pronounced the five letters, the E stated, "We'll be working with those letters."

The E then began to orient the S to the task he would be assigned.

"On the screen in front of you, you will see first the name of a country, and then you will see a map of that country.

"Remember, you will see first the name of the country and then the map. Your task will be to remember only the first letter of the name for each map. After you have seen all the names and maps once, you will be tested to see how many correct letters you remember. You will see the maps only and not the names. Then, you will see the names along with the maps again."

The S was asked if he knew what a clue* was. In all instances the S's answered in the affirmative. If a S volunteered a definition, he was permitted to present it. If not, the E said, "A clue is a hint which helps us solve a puzzle or a problem, isn't it?"

"To help you remember the correct letters, I will give you a different clue for each map. Please say each clue out loud while the map is on the screen. Remember now, wait until the map appears on the screen before you say the clue.

"Try to remember your clues from trial to trial; but I will help you remember them as long as you need such help.

"Now let's take an example of a clue we might use. Suppose that Mexico were a country which we wanted to learn. Your clue might be, 'M -- banana.' M is the letter we want to learn and banana is the clue to help us remember that the letter M and the map of Mexico go together. You know that a banana is curved like this. [Here the E made a curved motion with his hand.] You may remember that the map of Mexico is also curved. [Again the E made a curved motion with his hand.] You would repeat the clue twice while the map appears on the screen in front of you."

All subjects received the foregoing instructions. Groups A,B,E, and F were further instructed as follows:

"Also as a part of your clue to the right name for a map, I want you to say out loud the color of each map as it appears. For example, you might say, 'M -- yellow banana,' or 'M -- green banana.'"

Each subject was asked to re-state the essential of the instructions. The E prompted the S if necessary in stating principal parts of the instructions. Very little prompting was needed. The experimental stimuli were then presented to the subject.

*Referred to above as a practice-strategy.

Appendix H

Total Errors to Reach Criterion on Training Task
Experiment III

Name Color

Grade level	N Initial letter				N̄ Initial letter			
	I		Ī		I		Ī	
	color relevance		color relevance		color relevance		color relevance	
	RR	II	RR	II	RR	II	RR	II
4th	6	8	9	57	3	3	5	19
	5	28	26	76	1	4	33	55
	10	16	8	62	11	4	1	68
	11	7	14	27	7	34	9	36
	16	15	14	27	1	4	4	17
	11	20	51	40	3	11	49	33
	5	12	12	60	1	12	8	10
	15	42	20	57	1	4	8	12
	79	148	155	394	28	76	117	250
3rd	8	28	52	40	8	18	33	25
	19	25	16	69	22	5	45	44
	22	22	17	69	9	11	32	45
	11	4	42	68	6	8	44	19
	60	79	127	246	45	42	154	133

Appendix I

Analysis of Variance of Errors
on Training in Experiment III

Source of Variation	df	Mean Square	F
N (Color naming)	1	2,053.50	11.52
I (Initial letter)	1	10,837.50	60.81
C (Color relevance)	1	3,775.04	21.18
G (Grade level)	1	1,446.50	8.12
N x I	1	92.04	.52
C x N	1	864.00	4.85
I x C	1	1,176.00	6.60
C x N x I	1	425.04	2.38
error	87	178.22	

Appendix J

Instructions for Experiment IV

You will be shown a series of slides on the screen directly in front of you. You will notice (during training trials) that each shape is associated with a specific word. Your task is to learn this association and verbally respond to each shape with the word you believe is associated with it.

There are eight different shapes but less than eight words. Therefore some of the words may be associated with more than one shape.

You will notice that the shapes are colored, but since the color will not always help you (on the test trial) you should try to concentrate on the associated shapes and words.

FOR CONFIRMATION GROUP ONLY - You will see the shape first and then the shape and word together (during the training trial). Before the word is added respond aloud with the word associated with that shape and guess at those you are not sure of.

You will first see some test slides to help you understand the task.

Do you have any questions?

TO BE SAID BEFORE TRAINING SLIDES - You are to study the slides now.

TO BE SAID BEFORE TEST SLIDES - You are to respond now and guess at those you are not certain about.

Appendix K

Stimulus Presentation Sequence

Training trial slides (ordered by response)

6	3	9	4	7	5	8	2
3	5	2	4	7	9	6	8
3	6	4	9	2	5	8	7
4	6	2	8	7	9	5	3
8	2	7	3	4	6	5	9
5	3	9	8	7	4	6	2
6	3	2	9	4	5	7	8
4	7	9	6	8	3	2	5
2	6	9	7	8	3	4	5
4	2	5	8	7	6	9	3

Test trial slides (ordered by response)

6	3	9	4	7	5	8	2
Red	Blue	Yellow	Green	Brown	Orange	Purple	Grey

Appendix I.

Instructions to the Subject

You will be shown a series of slides on the screen in front of you. You will notice that each shape is associated with one number. Your task is to learn this association and verbally respond to each shape with the number you believe is associated with it.

There are eight different shapes as well as eight different numbers running from two through nine inclusive. Each shape and each number will appear only once on a given trail.

You will see the shape alone first and then the shape and number together. After the first time through you are to respond aloud with the number you think is associated with the shape, before the number appears on the screen. Respond even if you are unsure of your answers.

At some point during the experiment you will see some different slides which may or may not be similar to the other slides. You are to associate one of the numbers with these slides also.

Do you have any questions?

Appendix M

General Experimental Design for Training Trials Identifying Cell by Number (Nine Subjects per Cell)

Shape discriminability (D)	Color relevance (C)			
	Relevant (R)		Irrelevant (I)	
	Criterion level (L)		Criterion level (L)	
	100% only	100% and 69%	100% only	100% and 69%
Low (LD)	1	2	3	4
Mixed (HDLD)	5	6	7	8
High (HD)	9	10	11	12

Appendix N

Summary of Raw Data

Subject	Cell number (see Appendix C)	Number of trials	69% (L)				100% (L)			
			S (T)		C (T)		S (T)		C (T)	
			E	H	E	H	E	H	E	H
1	6	5					3	2	1	2
2	10	14	1	4	2	4	0	2	0	1
3	7	8					0	2	3	4
4	2	25	3	4	1	1	1	4	1	1
5	9	7					0	0	4	3
6	8	8	0	2	3	4	0	0	4	4
7	4	24	2	2	4	2	0	0	3	4
8	5	7					0	3	1	2
9	4	22	0	2	4	4	0	0	2	4
10	1	10					3	2	1	2
11	1	19					3	4	3	3
12	7	44	0	4	4	3	0	0	4	4
13	3	27					2	2	0	2
14	5	19					0	2	2	4
15	10	7	1	1	2	3	1	0	3	2
16	9	12					1	0	3	2
17	12	10	1	0	4	3	0	0	3	4
18	3	29					1	0	4	4
19	11	6					1	0	4	4
20	8	20	0	4	4	3	0	0	4	4
21	6	16	0	2	1	1	0	2	1	1
22	12	25	0	1	4	4	0	0	3	4
23	11	12					0	0	2	4
24	2	11	4	3	4	2	1	4	1	1
25	11	10					0	0	3	4
26	4	28	1	4	4	4	1	0	3	3
27	10	6	0	1	3	2	0	0	1	1
28	6	12	0	2	3	2	0	2	2	1
29	1	14					2	4	0	3
30	3	22					0	2	4	4
31	7	9					0	2	4	4
32	12	8	0	2	4	4	0	0	4	3
33	8	6	0	0	4	3	0	0	4	4
34	9	18					0	0	4	4
35	5	6					0	3	0	1
36	2	15	4	4	1	3	2	4	1	1

Subject	Cell number (see Appendix C)	Number of trials	69% (L)				100% (L)			
			S (T)		C (T)		S (T)		C (T)	
			E	H	E	H	E	H	E	H
37	6	10	1	2	4	3	0	0	2	2
38	2	11	3	3	1	2	1	2	2	1
39	12	21	0	1	4	3	0	0	3	3
40	10	7	4	3	2	2	0	0	1	1
41	8	9	0	2	3	4	0	0	4	4
42	4	23	1	1	4	4	1	0	4	4
43	3	24					1	1	4	3
44	7	18					0	4	2	3
45	5	18					1	3	3	3
46	9	18					2	0	3	2
47	11	21					0	0	4	4
48	1	19					2	2	1	1
49	12	8	0	0	3	4	0	0	4	4
50	7	17					0	0	4	3
51	10	5	1	0	2	3	0	0	0	0
52	11	13					0	0	2	2
53	4	30	2	4	4	4	1	2	4	4
54	6	15	1	2	4	4	0	3	1	1
55	8	15	1	4	4	4	0	0	4	4
56	9	12					0	1	2	4
57	3	16					0	0	4	4
58	5	7					0	1	3	3
59	1	12					1	4	1	2
60	2	5	4	4	1	0	1	3	1	0
61	10	12	0	2	4	4	1	0	3	4
62	12	9	0	0	4	3	0	0	4	3
63	6	12	0	4	0	2	1	4	1	2
64	1	30					1	2	3	2
65	2	14	3	2	1	2	1	1	3	2
66	5	9					1	2	1	2
67	9	24					2	1	2	1
68	3	21					0	0	3	4
69	11	7					1	0	4	4
70	7	18					0	0	4	3
71	8	12	0	2	4	4	0	0	4	4
72	4	23	2	2	4	4	0	0	4	2

Subject	Cell number (see Appendix C)	Number of trials	69% (L)				100% (L)			
			S (T)		C (T)		S (T)		C (T)	
			E	H	E	H	E	H	E	H
73	5	13					2	4	3	2
74	1	19					3	4	0	3
75	4	56	0	3	4	4	0	0	3	4
76	12	11	0	1	4	4	0	0	4	4
77	3	17					0	1	3	4
78	7	21					0	0	4	4
79	11	12					0	0	3	4
80	8	21	1	2	4	3	1	0	4	3
81	2	10	2	4	1	2	1	3	0	2
82	6	10	1	4	3	4	2	2	0	4
83	10	16	3	3	1	4	1	0	3	3
84	9	12					0	1	3	3
85	12	11	1	0	3	3	0	0	3	3
86	10	14	2	0	2	1	1	1	3	2
87	9	9					2	1	1	2
88	3	25					0	1	3	4
89	4	17	2	2	4	4	0	2	4	4
90	2	21	1	4	2	1	3	3	3	1
91	6	4	1	3	1	4	0	0	1	1
92	8	18	0	1	4	4	0	0	4	4
93	11	13					0	0	4	4
94	5	15					0	4	2	1
95	1	11					3	3	1	1
96	7	5					0	0	3	1
97	1	6					3	4	0	0
98	11	5					0	1	3	4
99	9	8					0	0	2	2
100	5	9					0	3	2	2
101	8	10	0	1	4	4	0	0	4	4
102	6	6	1	0	2	1	0	1	1	1
103	7	15					0	0	4	3
104	2	17	3	3	2	1	3	3	0	0
105	10	5	0	0	1	3	0	0	1	2
106	12	11	1	2	4	4	0	0	4	4
107	3	38					1	3	3	4
108	4	33	2	4	4	4	1	1	3	4

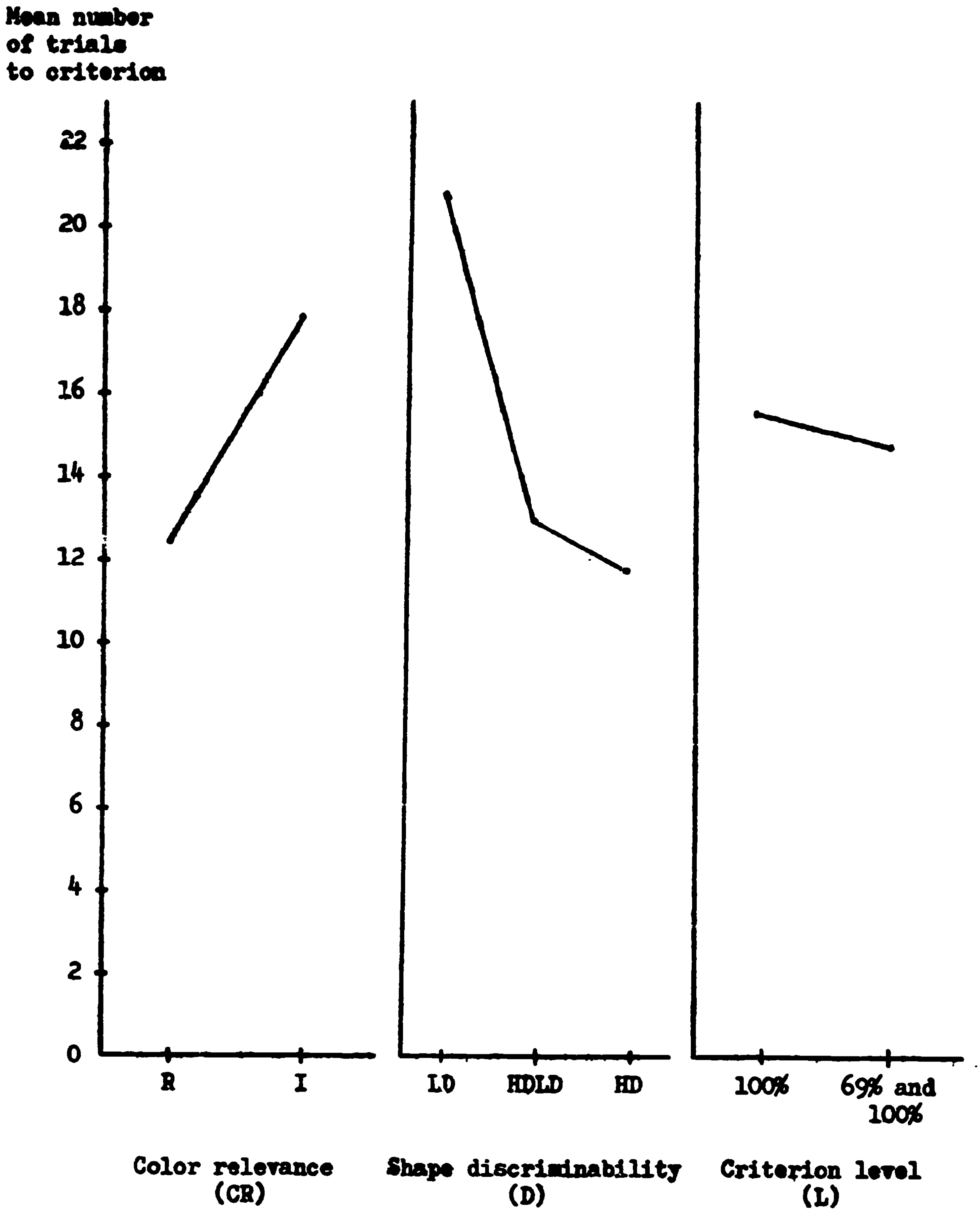
Appendix O

Craftint Colors Used in Shape Relevant (R) Condition and Color (C) Test

Red	Color Match #58
Blue	Color Match #129
Yellow	Color Match #3
Green	Color Match #169
Brown	Color Vu #56
Orange	Color Match #25
Purple	Color Match #82
Grey	Color Vu #10

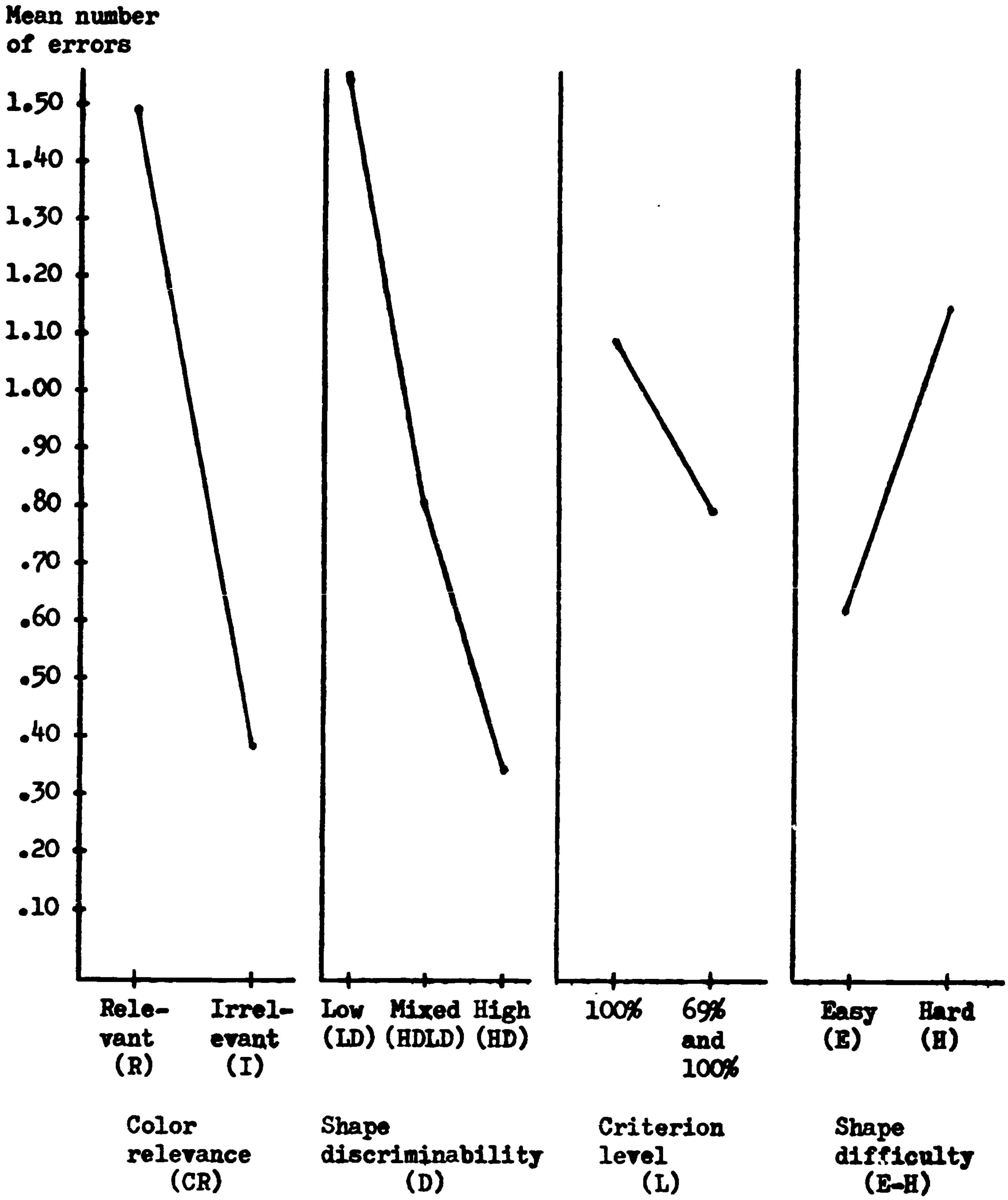
Appendix P

Mean Number of Trials to Reach Criterion Level for Subjects Grouped by Color (CR), Shape (D), and Criterion Level (L)



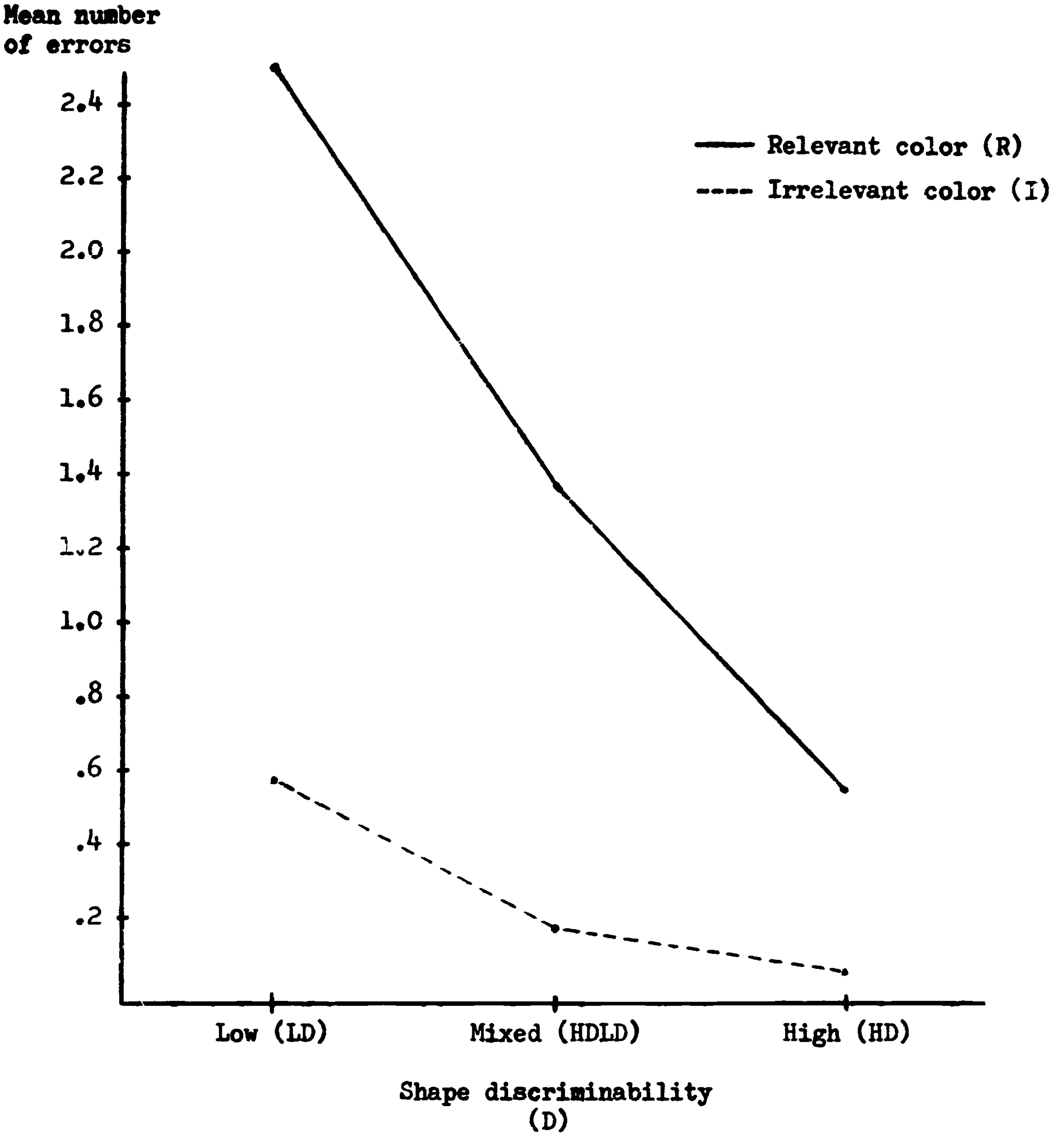
Appendix Q

Mean Number of Errors on Shape Only (S) Transfer Test (100%) for Two Levels of Color Relevance (CR), Three Levels of Shape Discriminability (D), Two Testing Criterion (L) and Two Levels of Shape Difficulty



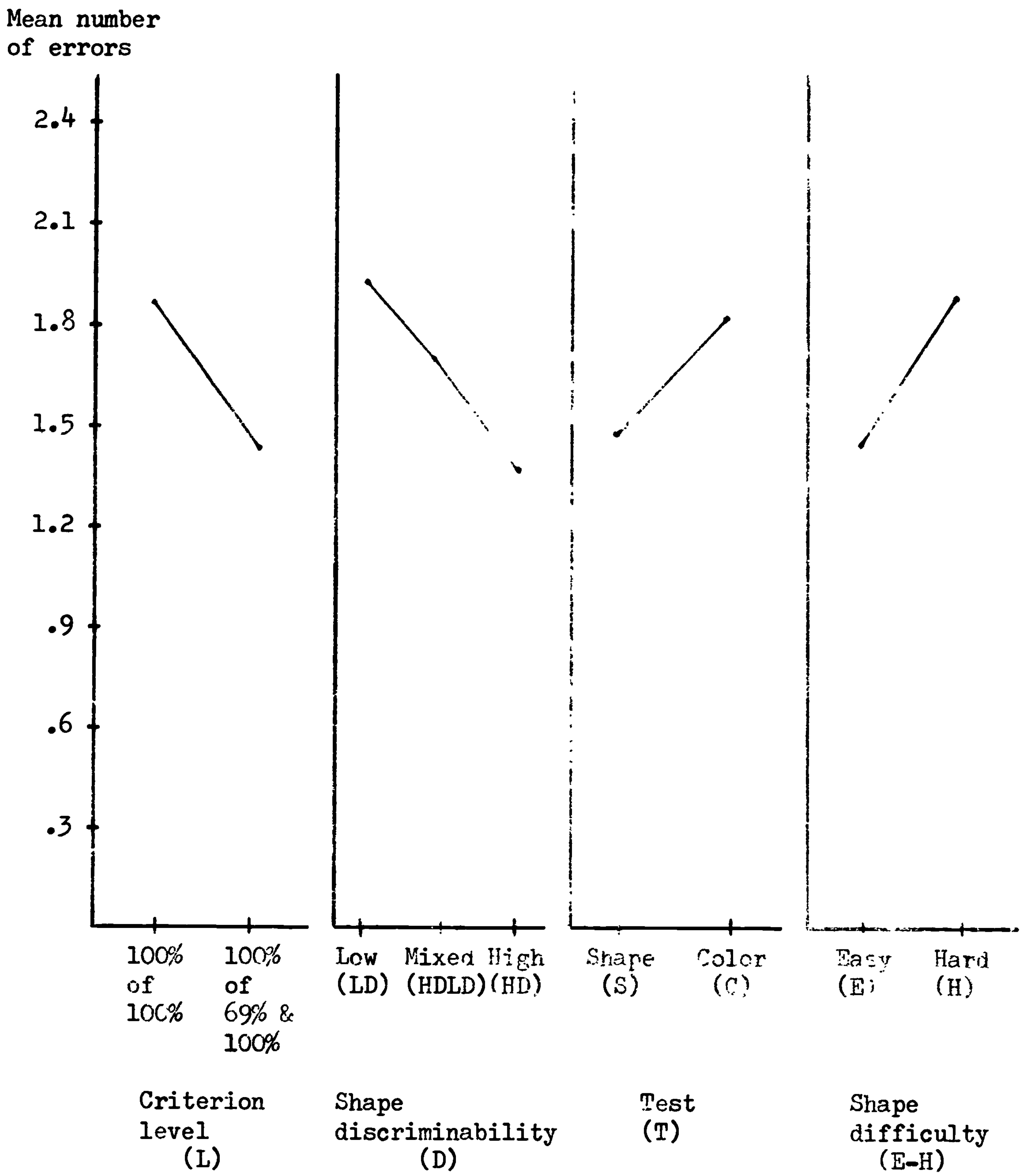
Appendix R

Mean Number of Errors for Shape Only (S) Stimuli Transfer Test (100%) for Three Levels of Shape Discriminability (D) and Two Levels of Color Relevance (CR)



Appendix S

Mean Number of Errors on Shape and Color Stimuli Transfer Test for Two Levels of Criterion (L), Three Levels of Shape Discriminability (D), Two Levels of Test (T), and Two Levels of Shape Difficulty (E-H)



Appendix T

Analysis of Variance of Number of Trials to Reach 100% Criterion as a Function of Color Relevance (CR), Shape Discriminability (D), and Criterion Level (L)

Source	df	MS	F
Color relevance (CR)	1	685.03704	14.69467***
Shape discriminability (D)	2	937.33333	20.10666***
Criterion level (L)	1	40.33333	< 1
CR x D	2	343.81481	7.37514**
CR x L	1	23.14815	< 1
D x L	2	48.44444	1.03917
CR x D x L	2	37.81481	.81116
Error	96	4475.33334	

**p < .01

***p < .001

Appendix U

Analysis of Variance of Errors on Shape (S) Transfer Test (100%) as a Function of Color Relevance (CR), Shape Discriminability (D), Criterion Level (L), and Shape Difficulty (E-H)

Source	df	MS	F
BETWEEN <u>S</u>s			
Color relevance (CR)	1	75.85185	114.37423***
Shape discriminability (D)	2	27.92130	42.10150***
Criterion level (L)	1	7.40741	11.16936**
CR x D	2	9.75463	14.70865***
CR x L	1	1.5000	2.26179
D x L	2	.3241	<1
CR x D x L	2	.01389	<1
Error (b)	96	.66319	
WITHIN <u>S</u>s			
Shape difficulty (E-H)	1	14.51852	29.65505***
CR x E-H	1	6.68519	13.65494***
D x E-H	2	7.22685	14.76132***
L x E-H	1	.90741	1.85344
CR x D x E-H	2	3.78241	7.72582**
CR x L x E-H	1	.07407	<1
D x L x E-H	2	.72685	1.48463
CR x D x L x E-H	2	.17130	<1
Error (w x E-H)	96	.48958	

**p <.01

***p <.001

Appendix V

Analysis of Variance of Errors on Shape (S) and Color (C) Transfer Test (100%) as a Function of Shape Discriminability (D), Criterion Level (L), Test (T), and Shape Difficulty (E-H)

Source	df	MS	F
BETWEEN Ss			
Shape discriminability (D)	2	6.29167	8.24034**
Criterion level (L)	1	16.66667	21.82872***
D x L	2	.09722	< 1
Error (b)	48	.76352	
WITHIN Ss			
Test (T)	1	16.66667	25.04383***
D x T	2	7.29167	10.95667***
L x T	1	1.18519	1.78090
D x L x T	2	.06019	< 1
Error (w)	48	.66550	
Shape difficulty (E-H)	1	4.16667	3.30580
D x E-H	2	34.76389	27.38141***
L x E-H	1	.01852	< 1
D x L x E-H	2	.14352	< 1
Error (w)	48	1.26041	
T x E-H	1	5.35185	8.21024**
D x T x E-H	2	3.78241	5.81077**
L x T x E-H	1	.16667	< 1
D x L x T x E-H	2	1.01389	1.55045
Error (w x T x E-H)	48	.65393	

*p < .05

**p < .01

***p < .001

Appendix W

Analysis of Variance of Errors on Shape (S) and Color (C) Transfer Test (69% for Conditions 2, 6, 10 and 100% for Conditions 1, 5, 9) as a Function of Shape Discriminability (D), Criterion Level (L), Test (T), and Shape Difficulty (E-H)

Source	df	MS	F
BETWEEN Ss			
Shape (D)	2	4.19907	3.51240*
Test criterion (L)	1	2.89352	2.42014
D x L	2	.28241	<1
Error (b)	48	1.19560	
WITHIN Ss			
Test (S-C)	1	16.11574	14.10679***
D x S-C	2	3.78241	3.3109*
L x S-C	1	1.33796	1.17117
D x L x S-C	2	1.9907	1.04959
Error (w x S-C)	48	1.14241	
Shape difficulty (E-H)	1	2.89352	2.02758
D x E-H	2	41.69907	29.40968***
L x E-H	1	.22685	<1
D x L x E-H	2	1.11574	<1
Error (w x E-H)	48	1.42708	
S-C x E-H	1	2.04167	2.74340
D x S-C x E-H	2	3.43056	4.60966
L x S-C x E-H	1	.22685	<1
D x L x S-C x E-H	2	.69907	<1
Error (w x S-C x E-H)	48	.74421	

*$p < .05$

***$p < .001$

Appendix X

Analysis of Variance of Errors on Shape (S) and Color (C) Transfer Test (69% and 100%) as a Function of Shape Discriminability (D), Criterion Level (L), Test (T), and Shape Difficulty (E-H)

Source	df	MS	F
BETWEEN Ss			
Shape (D)	2	5.47685	3.30217
Error (b)	24	1.65856	
WITHIN Ss			
Criterion level (L)	1	33.44907	30.01073***
D x L	2	.33796	< 1
Error (w x L)	24	1.11457	
Test (S-C)	1	8.56019	6.84185*
D x S-C	2	3.14352	2.51250
Error (w x S-C)	24	1.25115	
Shape difficulty (E-H)	1	2.44907	1.61349
D x E-H	2	37.00463	24.38686***
Error (w x D)	24	1.51740	
L x S-C	1	.00463	< 1
D x L x S-C	2	.72685	.85442
Error (w x L)	24	.85069	
L x E-H	1	.11574	< 1
D x L x E-H	2	1.58796	1.76577
Error (w x L)	24	.89930	
S-C x E-H	1	3.37500	4.76217*
D x S-C x E-H	2	2.37500	3.35115*
Error (w x S-C)	24	.70871	
L x S-C x E-H	1	.78241	.78514
D x L x S-C x E-H	2	.08796	< 1
Error (w x L x S-C)	24	.99652	

*p < .05

***p < .001

Appendix Y

Number of Correct Responses on the Color Test Only ($C\bar{S}$), Shape Test Only ($\bar{C}S$), Both Color and Shape Test (CS), or Neither Test ($\overline{CS}$) for Ss Trained Under Color Relevant Conditions

	Criterion Level (L)							
	69%				100%			
	Responses correct				Responses Correct			
	$C\bar{S}$	$\bar{C}S$	CS	$\overline{CS}$	$C\bar{S}$	$\bar{C}S$	CS	$\overline{CS}$
SUBJECTS TESTED AT 69% AND 100%								
Low Shape Discriminability (LD)								
1	3	1	1	3	3	0	3	2
2	2	1	0	5	3	1	3	2
3	4	0	0	4	4	0	2	2
4	3	0	2	3	2	2	3	1
5	7	0	0	1	4	1	3	0
6	3	2	2	1	1	4	2	1
7	3	0	2	3	3	1	3	1
8	3	1	2	2	3	2	1	2
9	3	0	2	3	6	0	2	0
Mixed Shape Discriminability (HDLD)								
1	1	1	5	1	2	2	4	0
2	3	3	1	1	3	3	2	0
3	0	3	3	2	2	3	3	0
4	1	5	0	2	0	4	4	0
5	0	5	1	2	2	1	4	1
6	2	0	4	2	2	0	3	3
7	1	3	0	4	1	3	2	2
8	1	2	2	3	0	2	6	0
9	1	3	4	0	1	2	5	0
High Shape Discriminability (HD)								
1	0	5	0	3	0	3	5	0
2	1	4	2	1	0	4	3	1
3	0	4	3	1	0	2	6	0
4	2	2	2	2	0	2	6	0
5	1	5	2	0	0	0	8	0
6	0	6	0	2	0	7	1	0
7	2	1	1	4	0	6	1	1
8	2	3	3	0	1	3	2	2
9	0	6	2	0	0	3	5	0

	Criterion level (L)							
	69%				100%			
	Responses correct				Responses correct			
	$C\bar{S}$	$\bar{C}S$	CS	$\bar{C}\bar{S}$	$C\bar{S}$	$\bar{C}S$	CS	$\bar{C}\bar{S}$
SUBJECTS TESTED ONLY AT 100%								
Low Shape Discriminability (LD)								
1					3	1	2	2
2					5	0	1	2
3					3	0	2	3
4					2	0	4	2
5					3	1	2	2
6					1	3	2	2
7					4	0	1	3
8					4	0	2	2
9					7	0	1	0
Mixed Shape Discriminability (HDLD)								
1					2	2	3	1
2					0	3	2	3
3					2	0	5	1
4					2	4	0	2
5					0	5	2	1
6					3	3	2	0
7					3	2	0	3
8					3	2	2	1
9					2	3	2	1
High Shape Discriminability (HD)								
1					1	3	2	2
2					0	4	3	1
3					0	8	0	0
4					1	4	2	1
5					0	5	2	1
6					2	2	3	1
7					1	5	2	0
8					1	2	3	2
9					0	5	3	0

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RELEVANT AND IRRELEVANT PICTORIAL COLOR CUES IN DISCRIMINATION LEARNING: Manipulation of Cue Relevance, Instructional Stimuli, Practice Procedures and Intervals, Shape Discriminability, Test Procedures and Age of Subject

FINAL REPORT

PERSONAL AUTHOR(S)

Black, Harvey B.

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RETRIEVAL TERMS

IDENTIFIERS

ABSTRACT Color coded shapes were stimulus terms in a series of five paired-associate experiments. The degree of relevance of the color coding was an independent variable in each of the studies. Children averaging ten years of age were Ss in the first three experiments and college students were Ss in the last two. In one or more of the experiments practice conditions were varied by imposing differing requirements of color or shape naming during practice, varying the length of anticipation interval, varying the color relevance and temporal location of the test trial and varying the instructions regarding the potential relevance of color. The stimuli were varied with respect to inter- and intra-life differences in discriminability and meaningfulness of shapes. Relevant color was found to facilitate acquisition to the compound stimulus in general and irrelevant, noisy color component was obtained. The degree of color selection was affected by the discriminability of the shape component, color relevance on test trials, instructions regarding color relevance and age of S. Selection of color cues was only partial and shape cues were also conditioned. Under appropriate conditions relevant color coding during training facilitated performance on transfer with only the shape components. The results were discussed in terms of S-R and hypothesis testing learning models and in terms of cognitive development of children. The results support the assumption that color coding effects may be interfering or facilitating depending upon factors other than the visual display characteristics and further that procedures assuring facilitation with children may be inappropriate with adults.

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